AR. 1947
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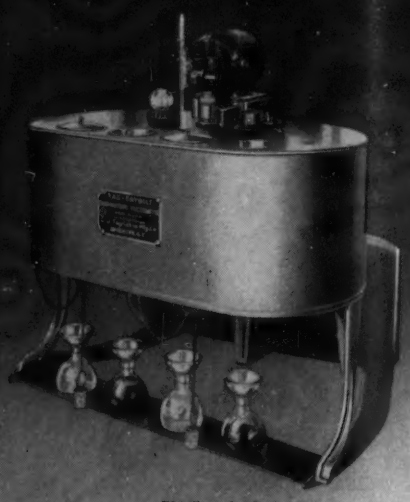
Instruments

HE MAGAZINE of MEASUREMENT and CONTROL

MAR 21 1947

Confidence



TAG — Saybolt Thermostatic Viscosi

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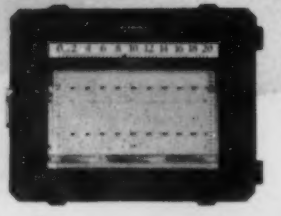

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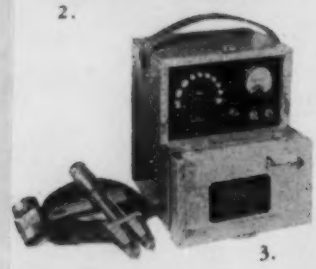

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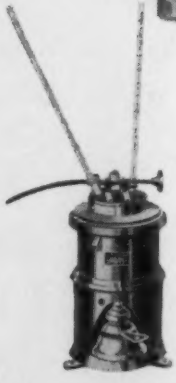
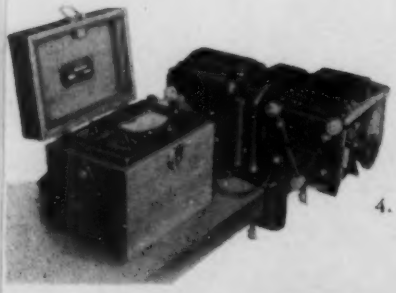


6.

For generations technicians, scientists and engineers have used TAG instruments with confidence. In Edison's day TAG made instruments which still perform satisfactorily. Today, TAG research continues its long range policy of developing and improving fine instruments to meet the demands of progressive industry. In the laboratory as well as in every major industry—Food—Steel—Plastics—Chemical—Rubber—Petroleum—Lumber—Textiles—TAG provides the ultimate in precision and dependability. Wherever the measurement and control of temperature, pressure and timing operations are vital to product quality, Specify TAG . . . with confidence!



4.

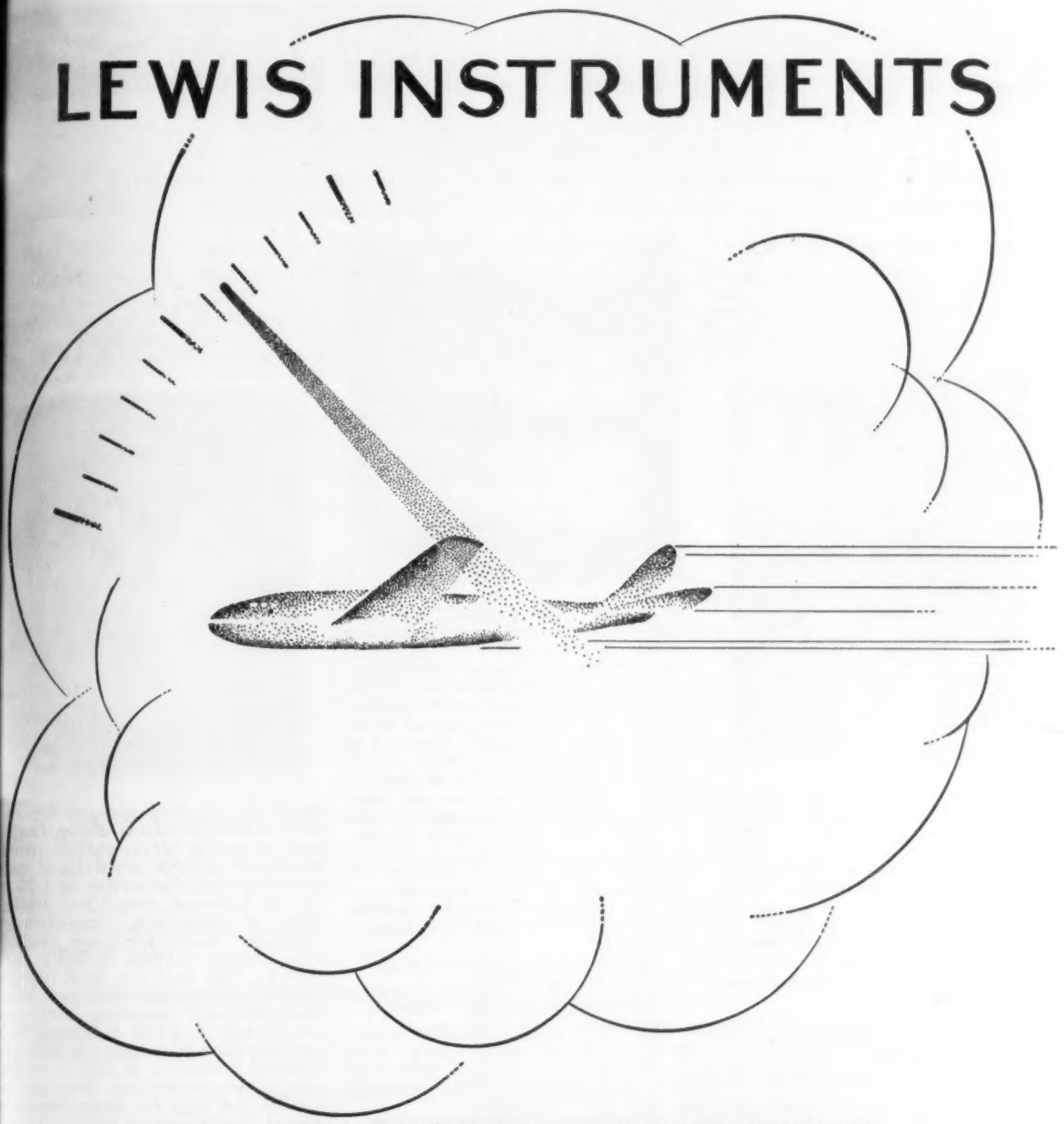
TAG

Instruments illustrated are: (1) TAG Automatic Recorder; (2) Celectray Recording Potentiometer; (3) TAG-Heppenstall Moisture Meter for Wood; (4) TAG-Heppenstall Moisture Meter for Grain; (5) TAG Automatic Recorder-Controller; (6) TAG A.S.T.M. Closed Tester; (7) Celectray Indicating Potentiometer.

5

C. J. TAG*liabue Division*

LEWIS INSTRUMENTS



FOR MEASURING TEMPERATURE

Electrically in AIRCRAFT

THE LEWIS ENGINEERING COMPANY

NAUGATUCK, • • • • • • • • • • • • CONNECTICUT

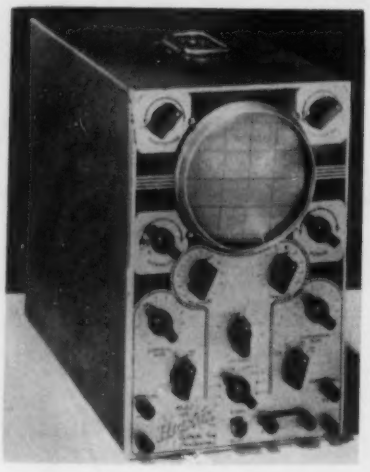
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 292.

General-purpose Oscilloscope

New "Model 195 General-purpose 5" oscillograph" is said to have exclusive feature of sinusoidal sweep with phasing control. It is designed for most accurate visual analysis of the wave-

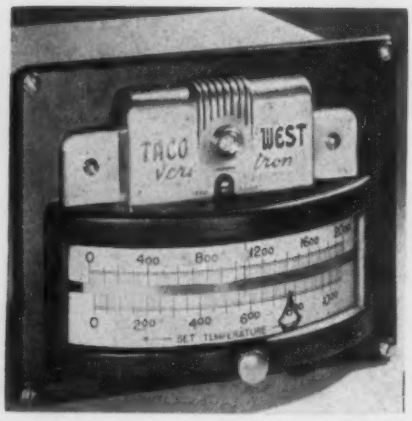


shapes of television, FM and AM signals. New 5 UP-1 cathode-ray tube with 5" screen facilitates analyzing causes of trouble in a receiver, and in aligning and servicing. Among features: extra-high grain vertical amplifiers allowing deflection of 1" per 0.05 volt input; phasing control for IF, RF, and discriminator alignment; sinusoidal sweep circuit.—*The Hickok Electrical Instrument Co., 10519 Dupont Avenue, Cleveland 8, Ohio.*

Please mention number 301 when filling out card

Pyrometric Controller

New "Veritron Electronic Pyrometric Controller" is a two-position controller with unique features including a new electronic circuit, ultra-compact design and simplified operation. It is specially suited for direct installation on industrial furnaces and plastic molding machines. Control is immediately established within an exceptionally narrow temperature range. Design permits instrument movement to operate a heavy-duty relay system without any physical contact or reaction effect on indicating pointer. Relay is built-in and has a load capacity of 3 kw. non-inductive. Electronic circuit requires no tuning or other adjustments by the user at any time; this is accomplished without using high-frequency oscillator systems, capacitance systems or mechanical clamping mechanisms. Control mechanism is said to be absolutely stable (chatter-free relay operation), unaffected by line voltage variation, surge effects, tube ageing or component changes. A pointer move-

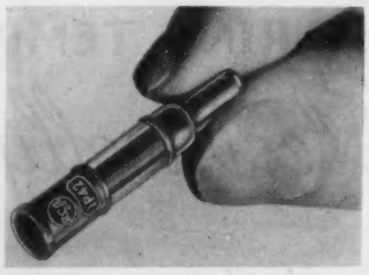


ment upon scale of 0.002" produces exacting relay operation. Measuring system is compensated for cold-junction deviation, moving-coil temperature coefficient, and magnetic errors. By newly-developed "Koolweld" welding process, all vital components of measuring system are rigidly fastened to insure a mechanical alignment, undisturbed by vibration, chock or ambient effects. Measuring system and electronic mechanism are separately housed in sealed units that plug-in to case. Instrument measures 7⅛" × 5¾" × 5¼", and may be either flush or surface mounted. A full 5" mirrored combination scale is standard.—*Taco West Corporation, 2620 South Park Avenue, Chicago, Ill.*

Please mention number 302 when filling out card

Miniature-size Phototube

New "RCA-1P42" is smallest phototube ever offered commercially: max. dia. ¼" and over-all length just under 1$\frac{13}{32}$". It is activated by light entering

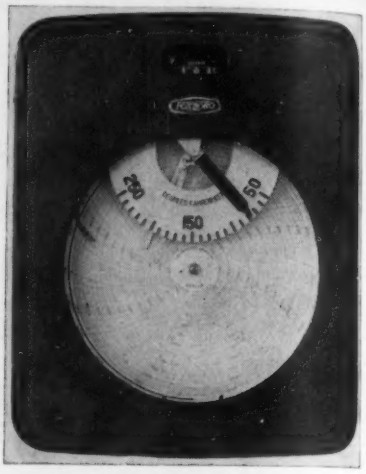


through a tiny window at its larger end. It is said to compare favorably with larger phototubes in sensitivity, is expected to find applications in devices where size of former phototubes has been a problem. In multiple-circuit control devices, it makes possible either smaller devices or more circuits in same space.—*Tube Dep't, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Please mention number 303 when filling out card

Automatic Controller with Continuous-balance Feature

New "Dynalog Electronic Recording Pyrometer" is said to embody "many revolutionary improvements on previous standard designs." It has no gal-



vanometer, no slide wire, no dry cell, and requires no standardizing. Continuous balancing action enables recording pen to traverse full width of chart in one second. Sensitivity is 1/30 of 1% of full-scale range. For applications of temperature measurement, "Dynalog" instruments are available with ranges between −200°F. and 2800°F., and for use with thermocouples or electric resistance bulbs. Recorders and recording controllers are offered. A giant indicating scale for long-distance reading is optional. Unusual versatility is said to be feature of new controllers: they are applicable not only for measurement or control of temperature but also humidity, force, strain, pH, speed and other process variables.—*The Foxboro Company, Foxboro, Mass.*

Please mention number 304 when filling out card

Multi-ray Lamp Unit for Visible and U-v.

New "Ray Master" multi-purpose lamp unit equipped with interchangeable burners for radiation of visible and ultraviolet radiations is said to meet a wide variety of special illuminating and ultraviolet applications in laboratory and industry. Following set of burners is furnished as standard equipment with each unit: (1) Short-wave u-v. (2537 AU) required for air and liquid sterilization, fluorescent activation, etc.; (2) Long-wave "black light" (3600 AU) employed for activation of paints, minerals, inks, etc.; (3) "White light"; (4) "North skylight," having a color temperature of 6500° K.,

2 QUICK WAYS TO CHECK MOISTURE CONTENT OF GASES

These G-E instruments give you quick and accurate analysis of moisture content in gases . . . whether your job requires a continuous record or just a spot check. One, the Dew-Point Indicator, is a portable device designed for spot checking. The other, the Dew-Point Recorder, is an automatic instrument which gives you a continuous record of the moisture content.

HOW CAN THESE INSTRUMENTS BE USED?

For measuring humidity of gases at compressor outlets, in storage systems, and at various points in plant piping systems.

For factory processes such as checking mechanical or chemical dryers furnace atmospheres, coolers, etc.

For analyzing moisture content of compressed gases.

For testing natural gases for humidity (to prevent freezing), partially burned city gases, and flue gases.

For experimental and process testing in research and testing laboratories.

DEW-POINT INDICATOR

For Quick Spot Checking. Here's the quick-test instrument. Portable and compact. You can spot check gases in less than a minute. Versatile, too! Several gases can be measured in sequence with little purging time between measurements.

How accurate is it? Exclusive of observation error, plus or minus three degrees F over the entire range. Measurement range extends from plus 110 degrees F to minus 100 degrees F. Easy to use: you simply read the dew-point temperature and use the conversion table to determine moisture content.

The instrument is self-contained in a small, portable black metal case. Especially suitable for checking the moisture content of finished gases, or making checks where constant record of variations are not required.

DEW-POINT RECORDER

for Continuous Operation

This instrument is designed to give, automatically, a continuous record of the dew-point temperature which is converted to moisture content. Must be permanently installed.

How accurate is it? Photoelectric system eliminates possibility of human error. Measures dew-point temperature with accuracy of better than plus or minus 5 degrees F at minus 90 degrees F, and plus or minus two degrees F above minus 20 degrees F. Measurement is from ambient to minus 90 degrees F.

Operation of the Dew-Point Recorder is easy. After initial installation, only a minor adjustment or two is necessary before putting into continuous operation.

FREE: Available now are publications on the Dew-Point Recorder and the Dew-Point Indicator and other gas analysis equipments. Check the ones you want and mail this coupon today for your free copies.

- ☐ GEA-4613—Dew-Point Measuring Equipments
- ☐ GEA-4561—Thermal Gas Analyzer
- ☐ GEA-4640—Leak Detector
- ☐ GEA-4390—Mercury Vapor Detector

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GENERAL ELECTRIC

BRADLEY

PHOTO ELECTRIC CELLS

Turn Light Into Current

Bradley's Luxtron* photocells convert light into electrical current. No additional source of voltage is required. Light-actuated Bradley cells provide control devices that give the longest life and need the least maintenance.

In addition to the housed model shown, with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings.

The shapes of Luxtron photocells vary from circles to squares, with every in-between shape desired. Their sizes range from very small to the largest required.

*T. M. Reg. U. S. Pat. Off.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

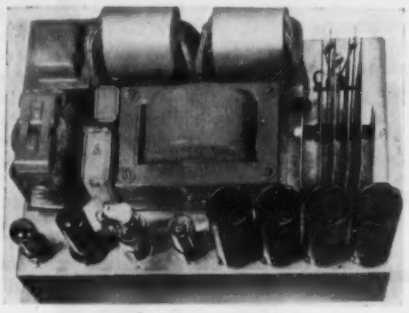
for routine work in color checking. A long-wave u-v. unit, not furnished as standard equipment, for use without visible light filters can be furnished for special applications in photochemistry.

Entire unit is self-contained and readily portable. Reflector is hinged to its supporting arm which is attached, by a universal joint, to an upright arm. Wide range of reflector positions is possible.—*George W. Gates Co., 43 Hempstead Turnpike, Franklin Sq., L. I., N. Y.*

Please mention number 304 when filling out card

Regulated D-c. Supply

New "Nobatrons" are said to make available regulated d-c. voltages at currents and stabilities previously available only with batteries. Six stand-



ard models operate on a 95-125-volt a-c. source of 50 to 60 cycles and provide currents of 5, 10 or 15 amperes with output voltages of 6, 12 or 28 respectively. Regulation accuracy is 0.5%; maximum ripple voltage (rms) is 1%; recovery time is 0.2 sec. Control features include "on-off" switch, voltage adjustment, control circuit fuse and pilot light. Models are available either for panel mounting or in cabinet.—*Sorensen & Company, Inc., 375 Fairfield Avenue, Stamford, Conn.*

Please mention number 305 when filling out card

Electrical Indicating Instruments

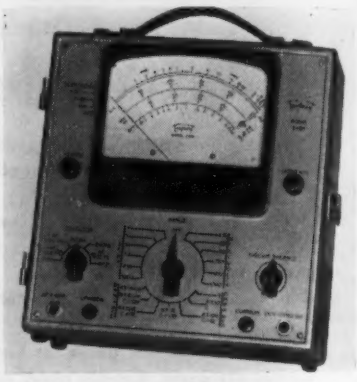
New complete line of 2" and 2½" panel instruments comprises two round-case and one rectangular-case forms available in a-c. and d-c. ammeters,

milliammeters, voltmeters and resistance indicators. All d-c. instruments are polarized-vane solenoid type; a-c. instruments are double-vane repulsion type. Both are accurate "well within 5%." Dials are metal, lithographed in black and white (colors supplied where required on quantity runs). All models are flush-mounting type. Zero adjusters are supplied when required on two of the d-c. case types. Maker announces one-year guarantee against defective workmanship or materials: instruments "will be repaired or replaced if sent to the factory postpaid with 25c handling charge within one year after date of purchase." Standard models are being stocked by "selected electrical and electronic parts distributors." — *Shurite Meters, 29 Hamilton St., New Haven 8, Conn.*

Please mention number 306 when filling out card

Circuit Analyzer

New "Model 2470 Appliance Tester" measures wattage consumption, current and line voltage of appliances and small motors under actual operating



conditions. Double-primary transformers and "Y" box resistors facilitate accurate testing on lines with unbalanced currents or voltages. Power used by smallest appliance is readily checked on scale range of 0-20 watts (fused to prevent damage from accidental overload). All switches and leads are ample to carry full load continuously. Five a-c. watt ranges at either 130 or 0.26 volts; four current ranges from 0.26 amperes at approx. 8 volts to 0-26 amperes at approx. 0.2 volts; two a.c.-d.c. volt ranges—0-130-260. — *The Triplett Electrical Instrument Co., Bluffton, O.*

Please mention number 307 when filling out card

Snap-action Switch

New snap-action millibreak switch is said to have uniform performance characteristics in mass production: run-of-lot switches are interchangeably usable in any shipment or from several different shipments. Moving member of heat-treated beryllium copper, with tongue ribbed for maximum stability, gains uniform characteristic from folded flat spring section which exerts high contact pressure and produces instant traverse. Non-rotatable actuator button assures application of actuating force to the same spot on tongue throughout life of switch. Contacts are silver, laminated on copper; moving contact has low mass for minimum con-

Design engineers in industry were faced with the need for a bellows with extra strength for service far in excess of normal limits.

Standard metal bellows, ideal for most pressures, just couldn't stand the gaff.

Fulton Sylphon application engineers, working closely with these customers, developed a product now wide and favorably known as the Sylphon Multi-ply bellows.

Multi-ply bellows consist of two, three and four metal tubes fitted closely together and then corrugated as a unit —just as standard bellows are corrugated. The result is extra strength . . . sufficient to withstand high pressures . . . without excessive loss of flexibility.

Precision built by specialists with more than 45 years' experience, these rugged multi-ply bellows . . . like all Fulton Sylphon products . . . are engineered to do their job better, longer, at less cost to you.

Why not find out today how they can be used profitably in your business? Catalog EE-1300, packed full of information and idea starters, is yours for the asking.

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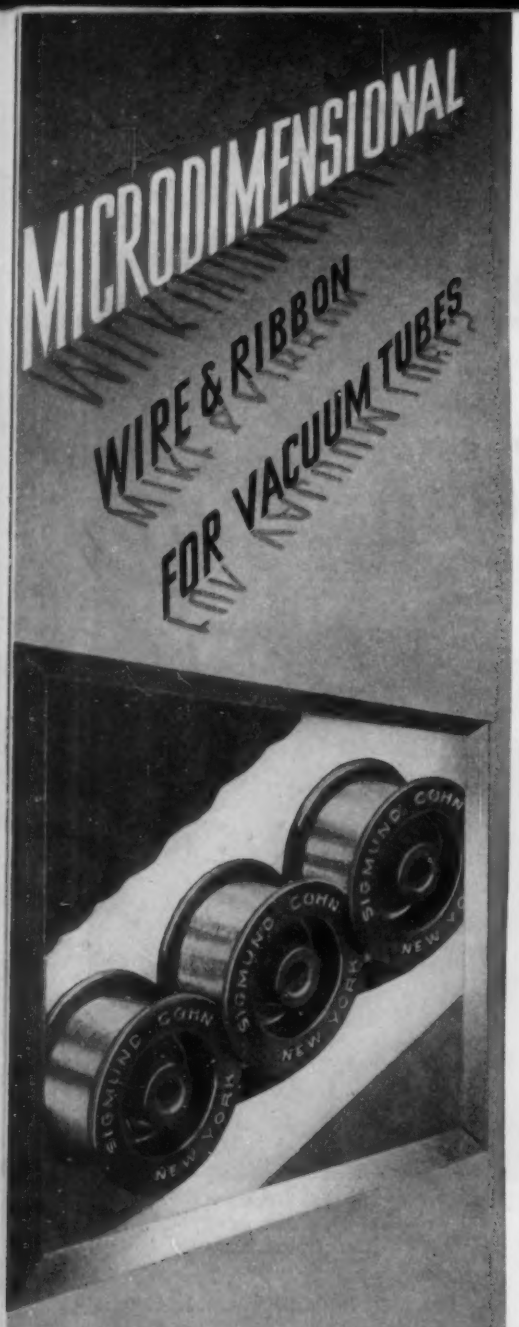
FIRST WITH BELLOWS

THE FULTON SYLPHON CO. KNOXVILLE 4, TENN.

FULTON SYLPHON

Temperature Controls Bellows Bellows Assemblies

Canadian Representatives, Darling Brothers, Montreal



Wires drawn to .0004" diameter.

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Ribbon rolled to .0001" thickness.

•

Special Alloys for individual requirements.

•

WRITE for list of stock alloys.

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44 GOLD ST. NEW YORK
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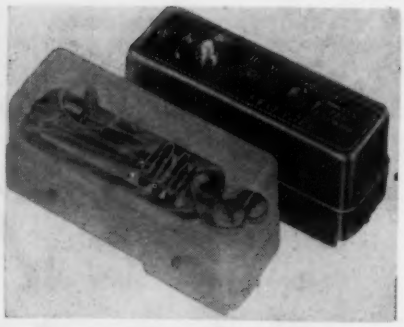


tact bounce. Overall dimensions of molded phenolic case: $1\frac{15}{16}$" × $1\frac{1}{16}$" × $1\frac{3}{16}$". Electrical ratings: 15 amp. 125 volts; 5 amp. 250 volts; ½ hp, 115-460 volts 60 cycles; all units s.p.d.t.—*Unimax Switch Corp., Subsidiary of The W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.*

Please mention number 308 when filling out card

Surface Comparator

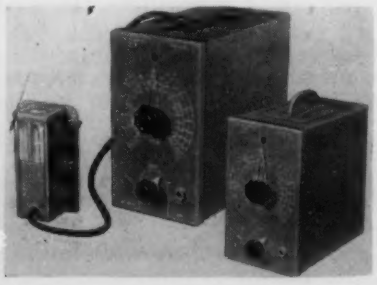
New "Pico Comparator" is a lightweight self-contained surface comparator for 100% surface inspection of machined parts. Operation in the shop

is simple and the results are indicated in microinches on either of two scales, one for "grind" and the other for "polish." New comparator can be used on flat and round work, odd shape pieces such as cams, thread flanks and ball bearings.—*Photron Instrument Co., 5713 Euclid Ave., Cleveland 3, Ohio.*

Please mention number 309 when filling out card

Intermittent-light-source Stroboscope

New "Model 1210" stroboscope employs a self-blocking oscillator in its power unit, provides for speed setting in four ranges between 10 and 800 cps. or 6000 to 48,000 rpm. It is suited to

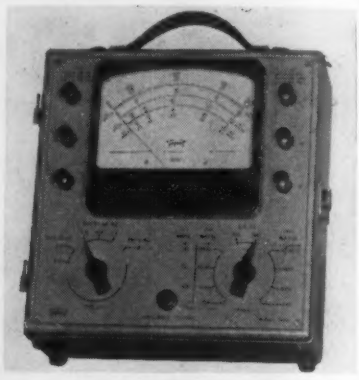


"stop" or "slow" rotary, reciprocating or vibrating movement by directing its light source at the moving mechanism; also to study mechanical stresses and strains under dynamic conditions and to determine their speed and rate. Main housing carries a smaller unit (cable-connected), containing stroboscopic lamp and having carrying handle on its back face, released from the main housing to direct the lamp at the work. Assembly includes a synchronized reed for calibration against line frequency on power input side which connects to a 110- or 220-volt 60-cycle power source. Unit can be calibrated to within ±3%. Main cabinet dimensions are $5\frac{3}{8}$" × $10\frac{1}{2}$" × $10\frac{1}{2}$". Weight is 19½ lbs.—*Communication Measurements Laboratory, 120 Greenwich St., New York 6, N. Y.*

Please mention number 310 when filling out card

Volt-ohm-milliammeter

New "Model 2450 Electronic Volt-Ohm-Milliammeter" is said to be most useful for FM and television work or any sensitive circuit requiring a high-impedance measuring device. Indicator



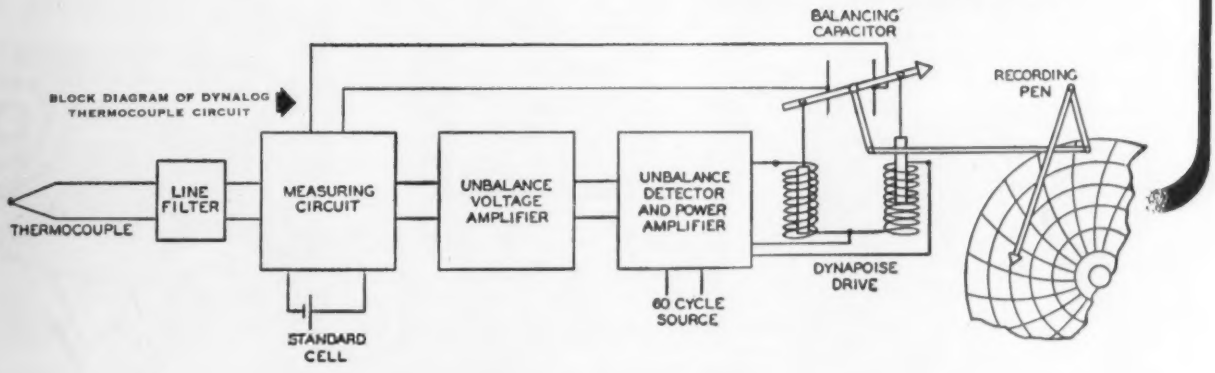
has 6" scale with three-color markings for readability. Two voltage regulator tubes are said to provide absolute stability for positive and negative voltages, within a line variation range of 90 to 130 volts. Ranges: d-c. volts: 0-2.5-10-50-250-500-1000; a-c. volts: 0-2.5-10-50-250-500-1000; d-c. milliamps: 0-0.1-1.0-10-50-250-1000; ohms: 0-1000 (midscale 10) -10,000-100,000; megohms: 0-1-10-100-1000; capacity in mfd: 0-.05-.5-5-50-500. — *The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Please mention number 311 when filling out card

Voltage-dividing Resistors

New wire-wound linear voltage-dividing resistor is available in single units or ganged in multiple on one shaft to provide independent voltage outputs for several related variables. New resistor is said to give a higher degree of operating accuracy and longer life than any low-cost unit of its kind. Accuracy is 0.1% in the 3" size, and 0.15% in the 2". Service life is guaranteed to exceed 1,000,000 cycles. Principal feature is flexibility afforded by ganging for related variables of resistance (or voltage output) versus rotation. Other features are wide angle of electrical rotation (351° and 355° respectively for 2" and 3" sizes); low torque requirement (< 1 oz.in. per

NEW DYNALOG CONTROLLER for THERMOCOUPLES



Gives STEPLESS balancing . . . Needs no standardizing!

FOR THE FIRST TIME in an automatically balanced thermocouple instrument, measurement of temperature is not only *continuous*, but STEPLESS. That's because Dynalog Thermocouple Instruments use a simple, variable, balancing capacitor instead of traditional slide wire.

FOR THE FIRST TIME, the measured voltage is compared directly to a Standard Cell. This eliminates the need for a dry cell battery requiring periodic standardization and replacement.

FOR THE FIRST TIME, in thermocouple measurement, the new Dynalog Recorders and Controllers offer you the advantages obtainable only in an instrument designed from start to finish for electronic operation . . . advantages which provide an unequalled combination of speed, sensitivity, and freedom from maintenance.

Whenever you need dependable, hairline control of temperatures, count on the unique advantages of these thermocouple-type recorders and controllers. Dynalog Controllers are made in air-operated (Model 40) types, and on-off or 3-position electric (Rotax) actions. Write for full details in Bulletin 397. **The Foxboro Company, 46 Neponset Ave., Foxboro, Mass., U. S. A.** Branches in principal cities.

FOXBORO REG. U. S. PAT. OFF.

ELECTRONIC INSTRUMENTS

What's YOUR special battery problem?

Here's a Tough One Burgess Engineers Solved.

THE PROBLEM

To build a battery in excess of 2000 volts within very limited physical specifications . . . to be sealed in a metal container . . . to have long shelf life . . . and to be equipped with 17 voltage taps.

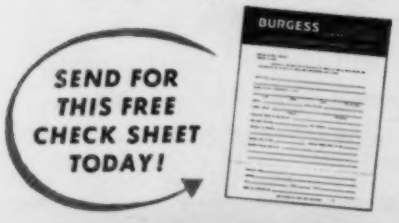
THE SOLUTION

A ruggedly constructed battery fully insulated, delivering *2025 volts,* and equipped with two plug-in and one wire lead terminal. Compact in size . . . built within a tight metal container.

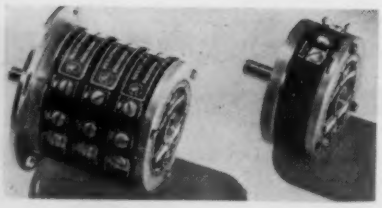
The Complete Burgess Facility
Design...Engineering...Production

. . . is at your disposal to provide the battery you need in the quantity you need . . . large or small.

Send for this free check-sheet . . . it enables you to easily and quickly provide Burgess engineers with all the information important to the design of a battery for your special requirements.



BURGESS BATTERY COMPANY
FREEPORT, ILLINOIS

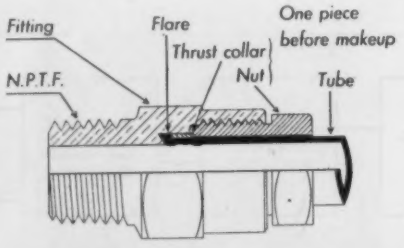


unit); power dissipation of four and five watts; and wide over-all resistance range from 100 to 100,000 ohms. Contact parts are composed of gold, platinum and silver alloys for long accuracy life. Applications include transmitter controls; servo-mechanisms; industrial measuring, recording and controlling instruments; computing and analyzing instruments; electromedical devices; radar navigational and fire-control equipment; telemetering; aircraft controls, etc.—*Fairchild Camera & Instrument Corp., Jamaica, N. Y.*

Please mention number 312 when filling out card

Tubing Fitting

New "Uniflare" two-piece self-flaring tube fitting may be applied to many varieties of tubing, is claimed to embody all advantages of compression

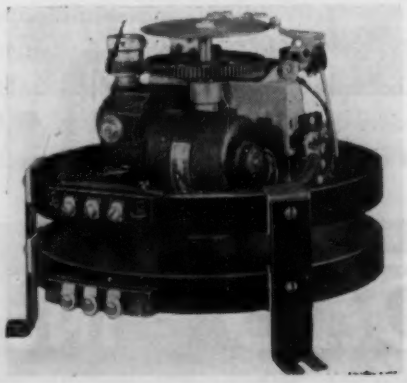


fittings and flared fittings, with none of usual disadvantages of either. It may be used effectively with tubing of various metals, is made in sizes from ⅛" to ¾", in all usual commercial shapes.—*Brockway Co., Naugatuck, Conn.*

Please mention number 313 when filling out card

Motor Drive for Rheostats

New "Bulletin 60A Motor Drive Units" are designed for remote and automatic operation of single or multiple stamped steel rheostats controlling generator voltages, motor speeds, lamp intensities, are available for a.c. and d.c. 115-or 230-volt operation; are suitable for control of 13" SS rheostats up to three plates. Standard units have 30- or 60-second travel "all resistance in" to

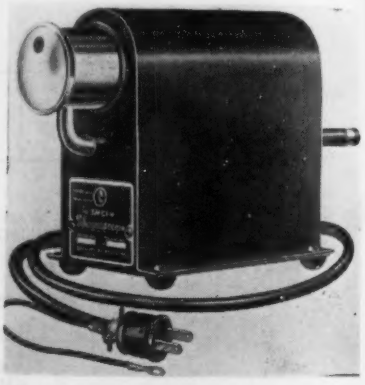


"all resistance out" position but can be furnished for shorter or longer travel time. Constructed on a 13" diameter steel plate, drives are intended for mounting on extended rheostat feet. Among features are adjustable limit switches, slip clutch and other parts readily accessible on removal of cover; and dust-tight spun aluminum cover. Dimensions: 13" diameter by approx. 7" high. On order, motor drive units can be furnished for high-speed return, with presettable limit switches, with longer or shorter travel time intervals and other special features.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Please mention number 314 when filling out card

Vacuum Gage

New "Skanascope" is said to be the first high-vacuum gage designed specifically for production work. It is said to employ an entirely new approach to vacuum measurement by indicating through color on a fluorescent screen (instead of by mean of pointer-and-scale) the total number of mole-

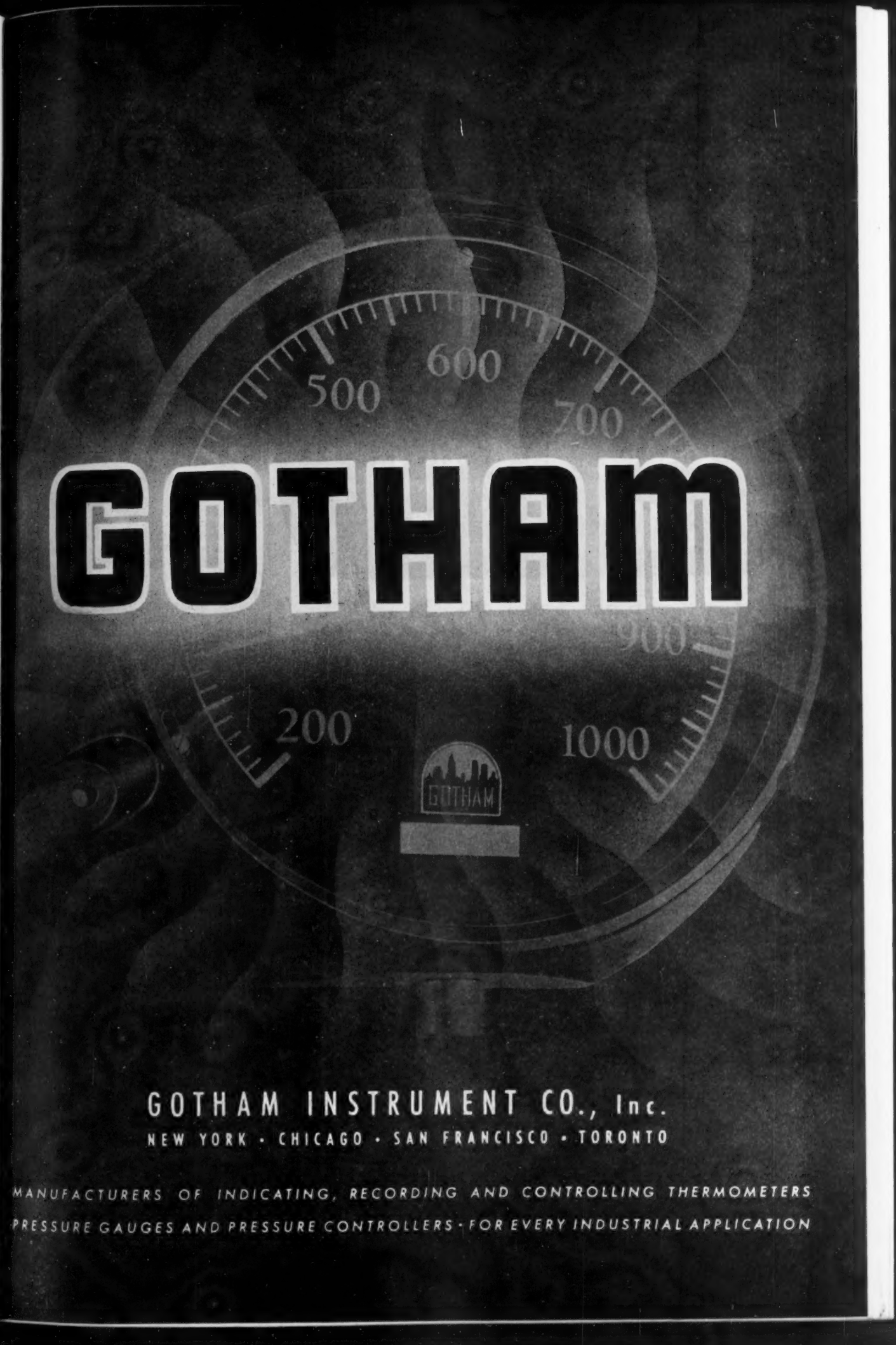


cules per unit volume in the vacuum system, including all residual gases and vapors, regardless of their condensability. Gage is designed to operate continuously, so that operative status of the vacuum system can be read by a glance at color screen at any time. "Skanascope" compensates for effect of temperature changes on the pressure, needs no calibration or zero setting. Basically automatic in operation, it may be permanently plugged into a standard electrical receptacle, since no current will flow until system is under vacuum. "Skanascope" is 8" high, 4½" wide, 12" long, weighs 7½ lbs., is safe for all vacuum installations. — *Distillation Products, Inc., 755 Ridge Road West, Rochester 13, N. Y.*

Please mention number 315 when filling out card

Portable 3" Oscilloscope

New "Model S-11-A Industrial and Television Pocketscope" is capable of measuring d-c. as well as a-c., weighs 8¾ lbs. and measures 11" × 7" × 5". Thus it is slightly larger than preceding "Model S-10-A" and is designed for greater utilization in more exacting fields of testing, measuring and research. (However, it does not replace the smaller general-purpose instrument.) It has a 3" screen; push-pull amplifiers for horizontal and vertical



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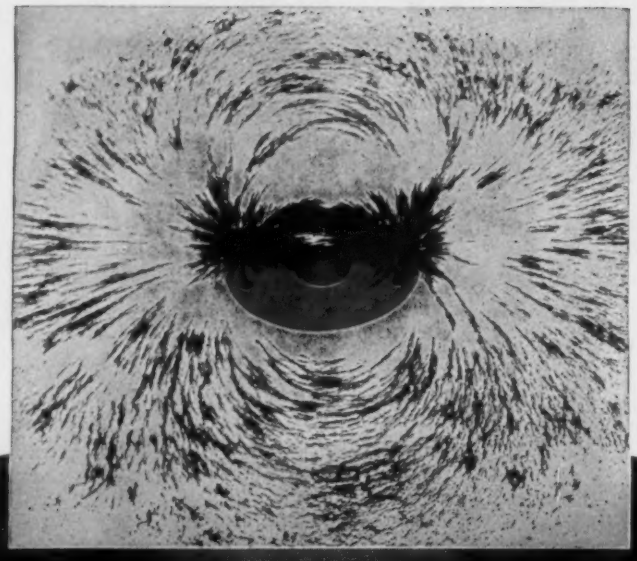

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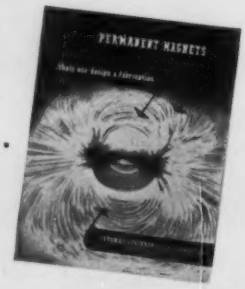

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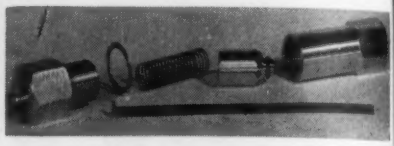
deflection; intensity modulation amplifier, linear time sweep from 3 cycles to 50 kc.; sensitivity and fidelity of intensity modulation amplifier suitable for television work, anti-astigmatic centering controls, trace expansion for detail observation, attenuators for a-c. as well as for d-c.; chassis completely insulated from input circuits for industrial safety; direct connections to deflecting plates and intensity grids accessible from rear; retractable light shield; detachable graph screen; fuse protection and functional layout of controls. — *Waterman Products Co., 2445 Emerald St., Philadelphia 25, Pa.*

Please mention number 316 when filling out card

Check Valve

New check valve has double seal said to eliminate leakage and loss of pressure even with grit in the system. With grit 0.010″ in diameter, valve is said to show no leakage or seepage at

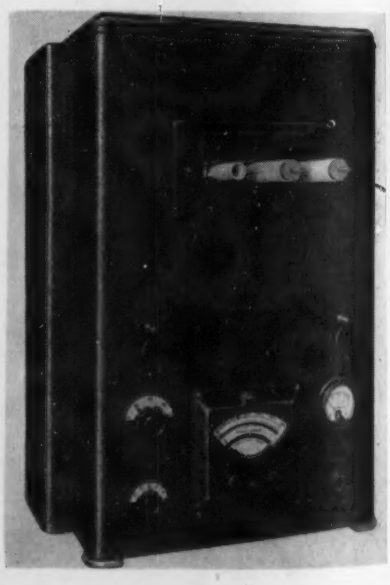


any pressure to 10,000 lbs./in.^{2}. Double seal is metal-to-metal seat plus rubber ring seal on check valve poppet: line pressure forces resilient ring to metal seat so that sealing force increases at higher pressures. Available sizes, ⅛″ to 1″ SPT, for pressures to 10,000 lbs./in.^{2} and any media not destructive to rubber or synthetic rubber.—*Mansfield & Green, 4601 Euclid Ave., Cleveland 3, Ohio.*

Please mention number 317 when filling out card

Laboratory Combustion Furnace

New "Hitemp" high-temperature (2900°F. Max.) laboratory combustion furnace may be used as a single-, double- or triple-tube unit. It comes ready to plug into 220-volt outlet, is supplied complete with power supply, ammeter, rotary power selection switches, heating elements, automatic temperature control and thermocouple. A combina-



Writing with your voice

Years ago Alexander Graham Bell dreamed of "a machine that should render visible to the eyes of the deaf, the vibrations of the air that affect our ears as sound." He never realized that dream, but his researches led to the invention of the telephone.

Today Bell Telephone Laboratories have turned the dream into a fact – translating the spoken word into readable pictures.

By this new invention of the Laboratories, the talker speaks into a microphone. Vibrations of the voice are unraveled through electronic circuits, and then are reassembled as luminous patterns which travel across a screen. Each syllable of sound has a distinctive shape and intensity.

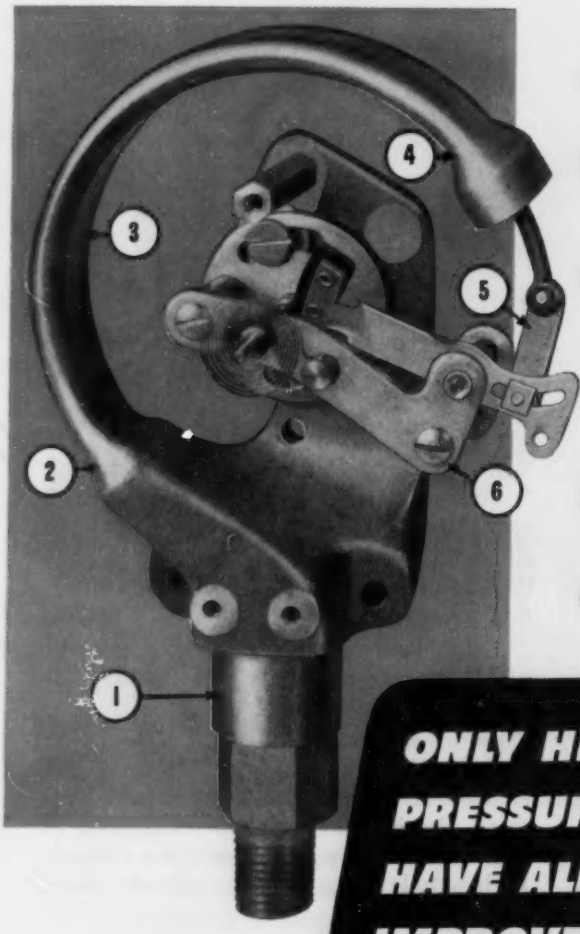
Science unravels speech

Visible speech is still in its infancy, and is not yet available to the public. But educators of the deaf are now evaluating it. Indications are that the deaf can learn to read the patterns and, by comparing the patterns their own voices make with the patterns of correct speech, can improve their diction.

Patterns of visible speech also provide a means for analyzing and recording sound in the study of phonetics and of languages. Eventually, visible speech may make possible visual telephony for the deaf.

This is but one of many contributions by Bell Telephone Laboratories to the understanding and control of sound.

BELL TELEPHONE LABORATORIES *EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE*



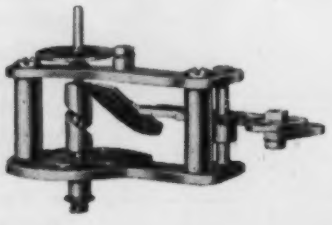
1. One-piece, drop-forged steel socket of streamlined design
2. Socket fused to KOREX steel Bourdon Tube
3. KOREX Bourdon Tube has smooth inner surface devoid of microscopic cracks
4. Forged steel tip fused to KOREX Bourdon Tube
5. Connecting link and screws of hard stainless steel, chrome plated and polished
6. Stainless Helicoid movement

ONLY HELICOID PRESSURE GAGES HAVE ALL THESE IMPROVEMENTS

These are not all the improved features of Helicoid Pressure Gages. They do serve to illustrate the fact that Helicoid is a better gage—one that will take the punishment of hard use and remain accurate through a longer life. Experience proves that a Helicoid Gage with KOREX Steel Bourdon Tube will safely withstand pressures of 50% in excess of the total dial graduation.

Many large users of gages have standardized on Helicoid. Write for our complete catalog which tells why.

In the Helicoid movement, contact between a polished, graphited Bakelite cam and a polished helical groove replaces the conventional gear and segment. Only Helicoid gages have this movement.



ACCO

TRADE MARK

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

tion disconnect switch and circuit breaker automatically protects furnace against overloads. Six ¾" diameter heating elements provide a radiating surface area of 128 in.^{2}.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.*

Please mention number 318 when filling out card

Voltage-rise Control for 35-kv. Dielectric Tests

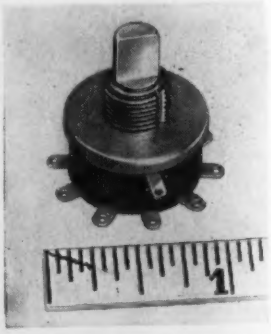
New "Type S-803 Seco Hypot Auxiliary" provides automatic control of uniformly-increasing output voltage of dielectric break-down (especially oil) testers in order to obtain accurate results and to conform to ASTM specifications. It has been designed to oper-

ate as an intermediary between a 35-kv. oil tester and a 115-volt single-phase source. Basic element is a "Powerstat" variable transformer driven by fast-starting and -stopping motor. Various switching arrangements enable "S-803" to be completely-automatic (push buttom) or semi-automatic. Specifications: input: 115 volts, single-phase, 60 cycles; output: 0-115 volts, 2.0 kva.; travel time: 11.5 seconds, voltage increment 3 kv. per second when used with a 35-kv. "Hypot" test set.—*The Superior Electric Co., 330 Church St., Bristol, Conn.*

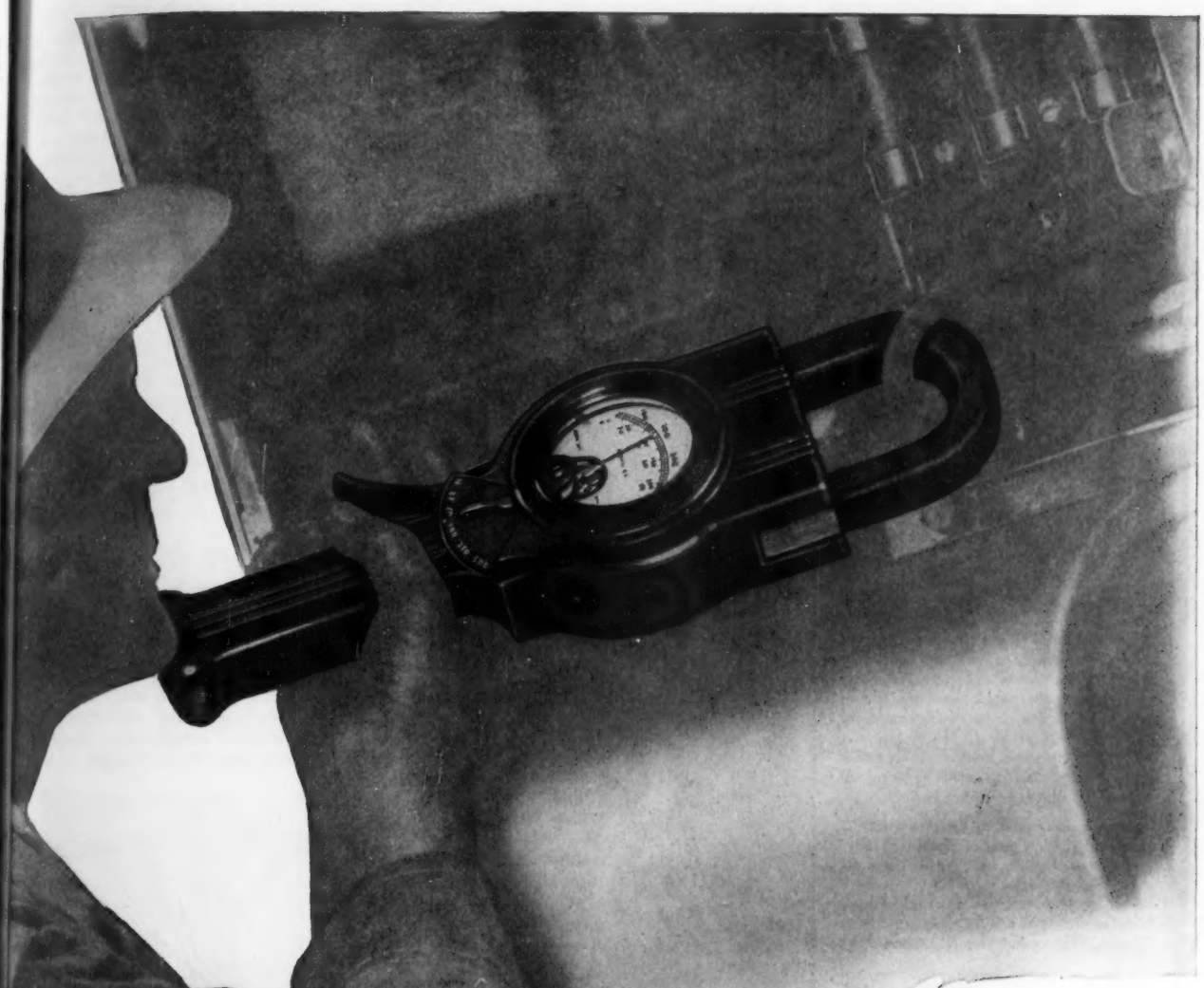
Please mention number 319 when filling out card

Miniature Switch

New "Series 5000 Roto Switch" is a miniature switch ¾" in diameter and 13/32" depth, yet has a contact pressure of 2½ lbs. and can be used in al-



most any circuit combination up to 5 amps., breaking up to 1 amp. at 110 volts. Featuring 360° rotation in either clockwise or counter-clockwise direction, switch can be moved from one position to another by turning through



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A time saver for either routine checks or trouble shooting. The jaws are simply hooked around the conductor and reading made without interrupting circuits or disrupting work. Three types available . . . top ranges of 500, 1000, or 2000 amperes. For further information see your local WESTON representative, or write . . . Weston Electrical Instrument Corporation, 591 Frelinghuysen Avenue, Newark 5, New Jersey.

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Silicone News

DC

New "divining rod" works through use of DC Silicone Fluid

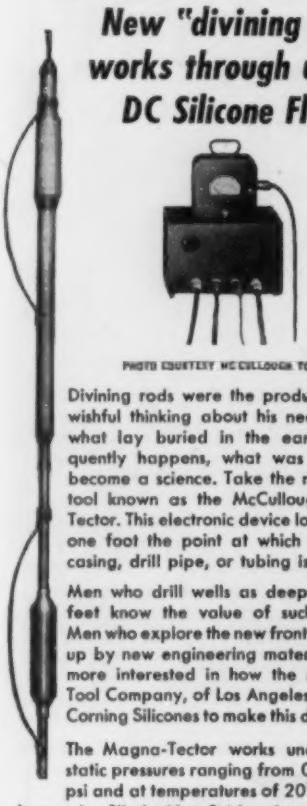

PHOTO COURTESY MC CULLOUGH TOOL CO.

Divining rods were the product of man's wishful thinking about his need to know what lay buried in the earth. As frequently happens, what was magic has become a science. Take the new oil well tool known as the McCullough Magna-Tector. This electronic device locates within one foot the point at which a string of casing, drill pipe, or tubing is stuck.

Men who drill wells as deep as 16,000 feet know the value of such certainty. Men who explore the new frontiers opened up by new engineering materials will be more interested in how the McCullough Tool Company, of Los Angeles, used Dow Corning Silicones to make this device work.

The Magna-Tector works under hydrostatic pressures ranging from 0 to 15,000 psi and at temperatures of 20° to 460° F. It must be filled with a fluid and provided with a pressure balancing device. Only DC Silicone Fluids retain a sufficiently constant viscosity over such a temperature range. Only DC Silicone Fluids retain good insulating properties at temperatures up to 460° F., and have sufficient lubricity, and inertness toward other insulating materials.

The pressure balancing device is a Silicone Fluid filled tube molded of Silastic*, the Dow Corning Silicone Rubber. The McCullough engineers found that no other material would remain flexible under such service conditions. New devices call for new materials. Dow Corning Silicone Products are available to meet specifications beyond the limits of conventional materials. Write for catalog No. P 1-6.

*TRADE MARK, DOW CORNING CORPORATION

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Dow Corning
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least number of positions. For example, by turning counter-clockwise, it may be moved from position 1 to 10 without going through 1, 2, 3, etc. Or, if desired, stops can be placed to allow rotation only through a given number of positions. "Series 5000" is made available in both shorting and non-shorting types. Shafts either for knob or screw adjustments are provided.—*Grayhill, 1 North Pulaski Road, Chicago 24, Illinois.*

Please mention number 320 when filling out card

Absolute Pressure Gage

New "Model-C absolute pressure gage measures in inches or millimeters of mercury. It is a U-tube manometer with one leg sealed and filled with mercury; the other an open tube connected to the source of pressure to be measured. Tube can be easily replaced, when necessary, with another tube, mercury-filled, shipped directly to location. Gage head fastens to body by a single wing nut. Available in wall- or flush-front mounting styles. — *Meriam Instrument Co., 10958 Madison Avenue, Cleveland 2, Ohio.*

Please mention number 321 when filling out card

Wide-range Oscilloscope

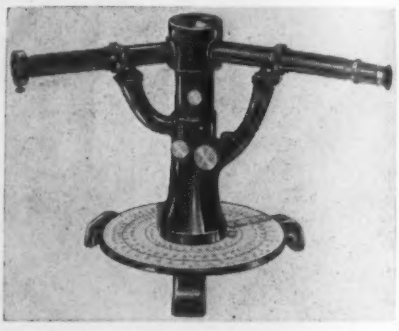
New "Type WO-79A" portable 3" oscilloscope makes possible accurate measurement and display of frequency components up to 6 Mc. in transient and pulsed voltages of the order of one microsecond. Incorporating many of advantages of expensive research instruments, it is designed for accurate measurement of the extremely-short sharp-fronted pulses produced by television synchronizing and deflection circuits, ignition systems, pulse generators, radar equipment, etc. Among features: centering controls permit expansion of a wave-form under test over a distance twice diameter of screen without visible distortion. Voltage amplitude of a signal can be determined by means of a calibrated voltmeter built into front panel. Triggered sweep permits photographic study of transient wave-forms, television signal expansion for checking square-wave time, and checking irregularly timed pulses. Intensifying amplifier increases brilliancy of the wave-form after time-base generator is triggered, permitting examination and photography of small, otherwise, faint, and extremely short pulses. Signal-triggered deflection, line frequency deflection, and blanking are among other features. Illustration shows unit with case removed and light-shield pulled forward. — *Engineering Products Dep't, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

WO-79A with case removed

Please mention number 322 when filling out card

Direct-reading Spectrometer

New spectrometer is of a new type, outstanding innovation being a pair of wave-length scales, one for use with a grating and one for use with a prism, making it direct-reading without need for any calculating from a formula and hence greatly speeding determination of large numbers of spectral lines. A circular scale and vernier scale is also



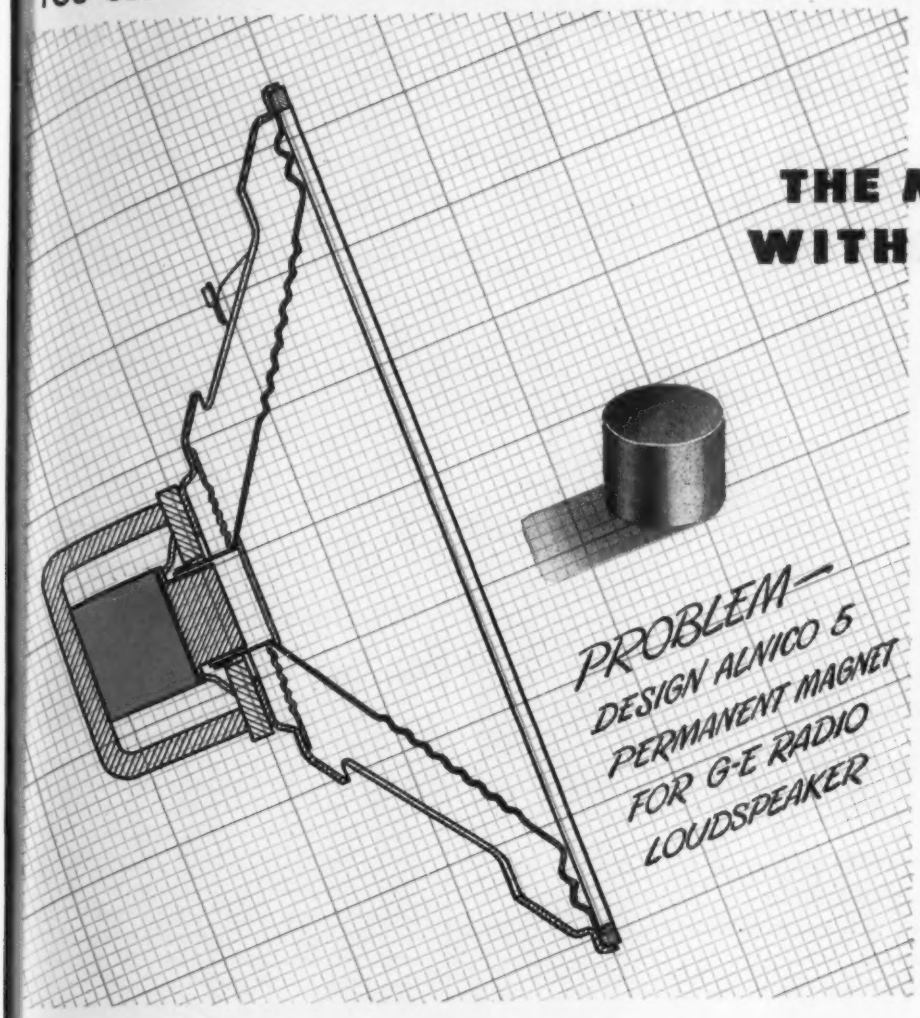
included for student use in measuring angle of prism, minimum deviation, etc. Accuracy is 20 A.U. "D" lines may be resolved. Achromatic lenses, tangent screw adjustment for telescope, adjustable slit, illuminated cross-hairs and other standard precision features are included. New instrument is said to be especially suited for student and research worker who needs to make many determinations in a minimum amount of time.—*W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago 10, Ill.*

Please mention number 323 when filling out card

Fatigue Tester

New "Sonntag Model SF-2" is a bench-type fatigue tester with "constant-force" loading feature for flexure fatigue tests on sheet stock of any material—metal, plastic, wood, etc. It requires no attention during test. Its design obviates need for any special device to maintain a constant force while the specimen is under test. Instead, it uses a revolving eccentric mass as a means of loading the specimen, so that load remains constant regardless of changes in deflection of

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS



THE MAGNET WITH A VOICE

A voice coil wound on an aluminum base moving in the field of an ALNICO 5 permanent magnet—that's the heart of the modern G-E loudspeaker. Current passing through the coil in the magnetic field causes the coil and attached cone to vibrate in proportion to the applied alternating voltage, thus producing sound waves. ALNICO 5 offers maximum energy with reduced size and weight, minimum losses and increase of sensitivity and power.

General Electric's precise quality control methods used throughout magnet production, plus accurate testing and rigid inspection assure you of receiving magnets of the highest uniform quality for your application.

Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. The large group of sintered and cast ALNICO alloys has been augmented by the lightweight, non-metallic mixture, VECTOLITE, and by the ductile permanent magnets, CUNICO, CUNIFE and SILMANAL. From such a wide choice of materials, you may now find a magnet better suited for your application or a material which will make possible new designs heretofore impractical or impossible.

General Electric engineers, backed by research and application experience, have acquired years of "know-how" in selecting the best permanent magnet material and properly designing magnets for thousands of products. These engineers are at your service. *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

PERMANENT MAGNETS

GENERAL ELECTRIC

CD47-JA3

SEND FOR NEW BULLETINS ON G-E PERMANENT MAGNETS

We shall be glad to send you upon request our new bulletins, CDM-1, "Permanent Magnets," and CDM-2, "Cast and Sintered Alnico, Catalog Supplement," both specifically designed to help you with your permanent magnet problems.

CDM-1 contains information about the characteristics and properties of G-E permanent magnet materials, their application and design. Listed in the catalog supplement, CDM-2, are sintered and cast Alnico permanent magnets available from stock. Proposed R.M.A. standard speaker magnets are included.

For your copies, please fill out the coupon below.

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specimen. A predetermined load is alternately applied to specimen, and resulting deflection is incidental. Its comparatively small size (15″×12″×32″) enables it to be placed in a cabinet during a test so that temperature and humidity can be controlled. Machine weighs 115 lbs., has an alternating force capacity of 20 lbs., speed of 1800 cycles per minute with 1″ travel of loading yoke.—*The Baldwin Locomotive Works, Philadelphia 42, Penna.*

Please mention number 324 when filling out card

Rotary and Stroke Counters

New "N" series of "Productimeter" double-deck rotary and stroke counters, made in both conventional and predetermined types, are designed for speeds of modern production machinery, as well as requirements of future machines. Design embodies several refinements for higher speeds and simplicity in construction. Case and front and back covers are of aluminum. Rotary models are double worm drive. Stroke models have upper row chain driven for quiet operation at high speeds. Predetermined models have a simplified switch mechanism.—*The Durant Mfg. Co., 1914 North Buffum St., Milwaukee 1, Wis.*

Please mention number 325 when filling out card

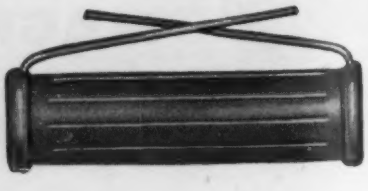
Wall Chart of Atoms

New 1947 edition of Hubbard Chart of the Atoms includes newly-discovered elements resulting from atomic bomb research, and 1947 atomic weights. All constants have been revised to correlate all recent research as applied to all of the 35 different characteristics of the atom. Manual accompanying chart has new tables and graphs of correlation of atomic structure with physical and chemical properties.—*W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago, Illinois.*

Please mention number 326 when filling out card

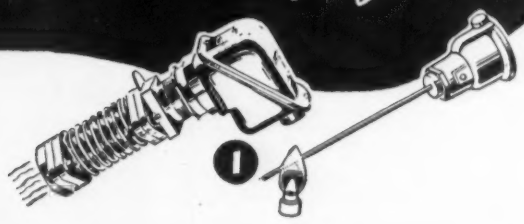
1%-accuracy Resistor

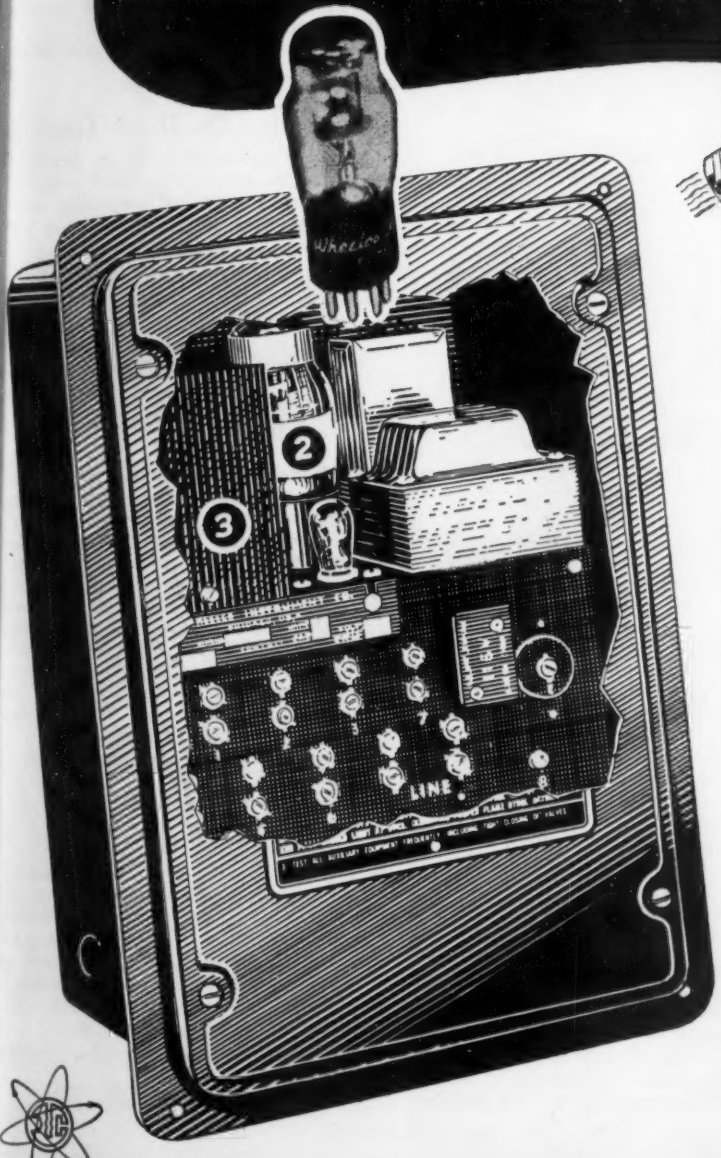
New "Nobleloy" non-inductive "X" type metal-film resistor is available in resistance values from ½ ohm to 50 000 ohms, for high-frequency application and wattage loads in sizes ½, 1, 2 and 5 watts. When used in d-c. circuits or



Buy Wheelco

Flame-otrol Combustion Safeguard





473

1. Operating on the principle of electrical conductivity of flame, the sensing element is an ELECTRODE for gas application. A FLAME-EYE (photo-electric cell) is used for oil. With flame failure, the resistance of the sensing circuit increases.

2. The increase in resistance due to flame failure is translated by the VACUUM TUBE into a large change of current, sufficient to operate the relay.

3. The RELAY operates to close the fuel valves. In addition to cutting the fuel off on flame failure, the Flame-otrol also actuates the relay to safe position in case of inadequate maintenance.

The trend is to Wheelco Flame-otrol Combustion Safeguards for protection of all fuel-fired furnaces, boilers, ovens, kilns, etc. Listed and approved by ASSOCIATED FACTORY MUTUAL LABS. and UNDERWRITERS' LABORATORIES.

WHEELCO INSTRUMENTS COMPANY

833 W. Harrison St., Chicago 7, Ill.

WHEELCO *Electronic* CONTROLS

Speed · Simplicity · Serviceability

STATHAM ACCELEROMETER

This 2 oz. Accelerometer may be used for vibration measurement on light structures with only an insignificant change in the characteristics of the structure. It is but 3/4 inches high, 1 13/16 inches long, and 1 1/2 inches wide. It is sensitive to acceleration normal to the base only.

It may be connected to any type of cathode ray oscilloscope or recording Galvanometer, usually without amplification. If only low frequencies or static accelerations are to be measured, a panel type microammeter may be used. Resistive in character, it is ideally suited for use in carrier systems.

Available in several ranges from ± 2 G to ± 50 G.

Statham Laboratories also makes Pressure Transmitters with full ranges of ± 0.2 psi to 0-10,000 psi, and Dynamometers.

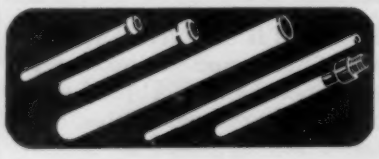
Write for Our Catalog.

STATHAM LABORATORIES INSTRUMENT MAKERS

8222 BEVERLY BOULEVARD
LOS ANGELES 36, CALIF.

MONTGOMERY TUBES

for Thermocouple Protection or for Radiant Target Sighting



Montgomery high refractory tubes, porcelain, mullite and corundum, are widely used in applications above 2000°F. They are available in all popular and special sizes.

We also manufacture Crucibles for laboratory analysis. Tell us your requirements.

WHEATSTONE CORPORATION

Manufacturers of refractory porcelains

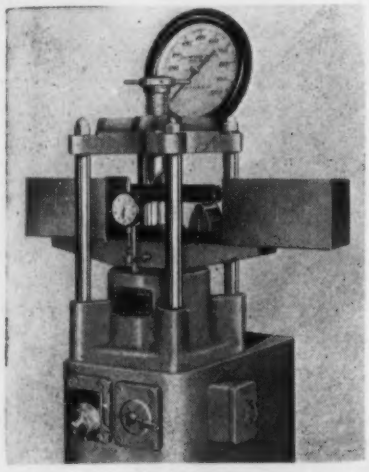
2436 READING RD., CINCINNATI 2, O.

circuits employing commercial frequencies, peripheral spiral method of calibration produces resistance values ranging from ½ ohm to 50 megohms with an accuracy of 1%. Resistance film is fired upon a high-density ceramic tube and coated with a high-temperature vitreous enamel. This process is said to make new resistor outstanding in permanency of resistance, zero voltage coefficient, low noise level, water repellency and high overload rating.—*Continental Carbon, Inc., 13900 Lorain Ave., Cleveland, Ohio.*

Please mention number 327 when filling out card

Transverse Tester

New "Model TR-1 Transverse Testing Machine" has a capacity up to 10,000 lbs., is hydraulically operated, is supplied with electric motor drive at

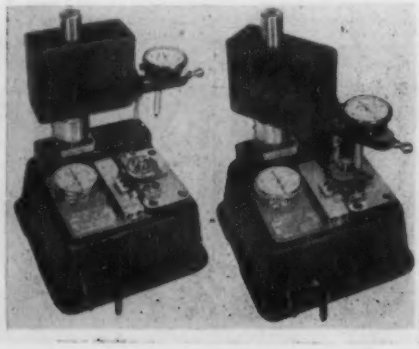


voltages to suit user's requirements. Load is applied automatically, at speeds to suit operator. A specially-constructed gage has maximum-indicating hand which remains stationary when specimen breaks. Gages may be calibrated in kilogram loads if desired. Specifications: 24" maximum span, 4" opening; floor space 26" × 20".—*Steel City Testing Machines Inc., 8843 Livernois, Detroit 4, Mich.*

Please mention number 328 when filling out card

Squareness-of-face Gage

New "Squareness-of-Face Gage" is a new type of gage. It checks relationships between the pitch diameter of a thread and the face of the part. It may be mounted on any Bryant Thread Gage. Operation: control lever withdraws thread segments behind guides, part is positioned and three thread segments are engaged (left photo); part is given one-third of a turn for all-over thread inspection, which is indicated on thread gage dial. Squareness-of-face gage is then swung into position (right photo) and a half-turn more checks right angularity which is indicated on the other dial. Control lever is then actuated, allowing part to be lifted from gage, thus eliminating unscrewing part off thread segments. No "feel" is necessary; unskilled operators can use gage at high speed. Each gage is furnished with a master setting ring. Various models cover capacities from ⅜" to 8" internal thread diameter.—*Bryant Chucking Grinder Co., Springfield, Vt.*



Please mention number 329 when filling out card

Sweeping Oscillator Tester

New "Mega-Sweep Jr." is described as a service man's simplified model of a standard laboratory sweeping oscillator currently installed in most FM

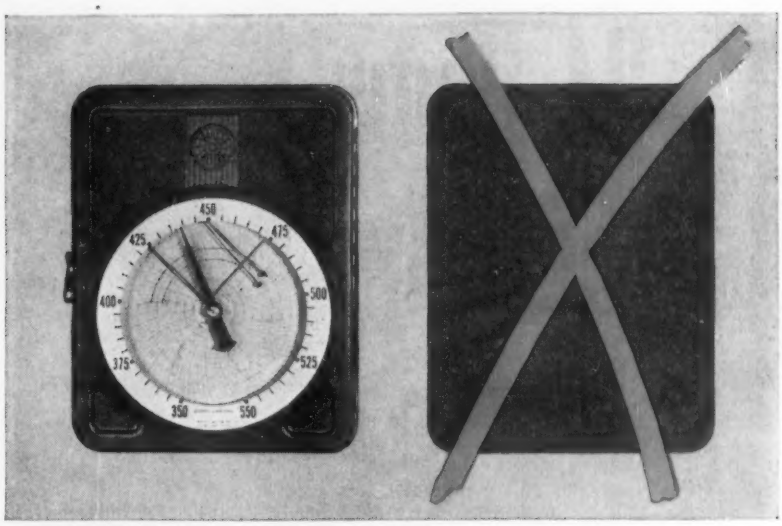
and television laboratories and in manufacturing plants. Outstanding feature is frequency sweep up to 30 Mc. over entire frequency spectrum of 400 kc. to 500 Mc. (When necessary, output frequency may be increased to 1000 Mc.) Thus sweeps are furnished all through color television frequency bands. Output frequency meter is calibrated to 900 Mc. Unit operates on 117-volt 60-cycle supply, weighs 20 lbs., measures 16" × 8" × 8".—*Kay Electric Co., East Orange, N. J.*

Please mention number 330 when filling out card

Spot-welding Timer

New "Type 30CR3" welding timer for interval timing of spot welding operations over a range of 3 to 120 cycles, meets specifications of NEMA class 1A Timers, is applicable to manual, air- or motor-operated welding equipment. Timing adjustment accuracy within 2%. By selection of terminals on panel, timer will provide beat or non-beat timing

Save Panel Space with Two Controlling Pyrometers in One Instrument



You can cut control panel space easily by using the Bailey Pyrotron Temperature Controller. This Potentiometer-Pyrometer can be furnished to record and control two separate temperatures at the same time.

Other Unusual Features of Bailey Pyrotron Dual-Temp Controllers

1. Null-balance measuring systems kept in continuous balance by inertia free electronic detectors and motor control systems.
2. Ample power for operation of control and alarm devices provided by reversible slidewire drive motors.
3. Usual Galvanometer replaced by sturdy electronic units.
4. Conversion of thermocouple emf to a-c by saturable core reactors containing no moving parts.
5. Maintenance simplified by easy accessibility and by interchangeable packaged units.
6. Careful leveling or protection against usual vibration not necessary.

● Each control system is actuated by a thermocouple which is always connected to the self-balancing potentiometer circuit. *Each temperature has its own independent system.*

A comparison of related temperatures can be made quickly as both records are on the same chart.

For details on this unusual thermocouple type Recording Controller ask for Bulletin 232. P-12

BAILEY METER COMPANY
1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO
Controls for Processing

TEMPERATURE	FLOW
PRESSURE	LEVEL
% OXYGEN	DENSITY
% COMBUSTIBLES	RATIO

24 Pages of Help!

on selection and application

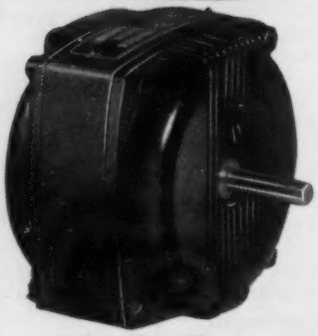
If you work up around 15,000 to 350,000 volts, 2 to 1000 kva, this 24-page bulletin is good news on high-potential test sets. Thirty-four test sets—completely engineered and built by G.E.—give you a choice of equipments that have been found by use to be most practical and economical for either the simplest or the most complex installations. For extra high voltages, cascade circuits are featured. Complete, proven designs save drafting, engineering time, assure quality performance. Write for Bulletin GEA-4559, to *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

high-potential test sets

GENERAL ELECTRIC

DEPENDABLE POWER FOR INSTRUMENT APPLICATIONS

The most vital part of many precision instruments is the electric motor drive. It must be accurate . . . and absolutely dependable. The quality of the motor must be equal to the quality of the instrument — in design, workmanship, and performance.



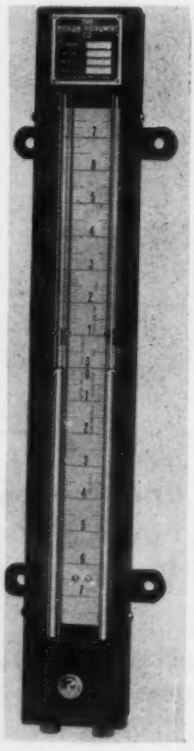
Bodine Type K motor, available with or without reducer.

Bodine engineers have spent over 40 years in the special field of designing and building fractional horsepower motors of the finest quality. Their wide experience in application of these motors to precision instruments can aid you in developing a motor drive for your instrument. Bodine Electric Co., 2244 W. Ohio St., Chicago 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

(initiation of timing cycle from momentary contact or sustained contact). Terminal panel is dead front so that operator cannot touch terminals when setting timing interval. Combinations of "Type 30CR3" are used when it is desired to control also other portions of welding cycle, such as squeeze, heat, cool, on and off periods. Timer operates on 115 or 230 volts 50-60 cycles; Power: 25 watts; Ambient temperature: 32° to 150°F.; Ambient relative humidity: 20% to 95%; Overall dimensions: 9⅞" × 6⅛" × 4¼"; Net weight: 8 lbs.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 331 when filling out card



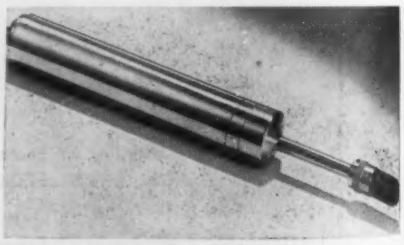
High-pressure Manometer

New "Model A-995" high-pressure manometer, for line operating pressures up to 400 lbs./in.², has a body of formed steel channel construction. Glass tubing is top grade, fully annealed. The two straight tubes are connected by cross drilling the lower end block. Unit is available for wall, front-of-board and flush front panel mounting. — *Meriam Instrument Co., 10958 Madison Avenue, Cleveland 2, Ohio.*

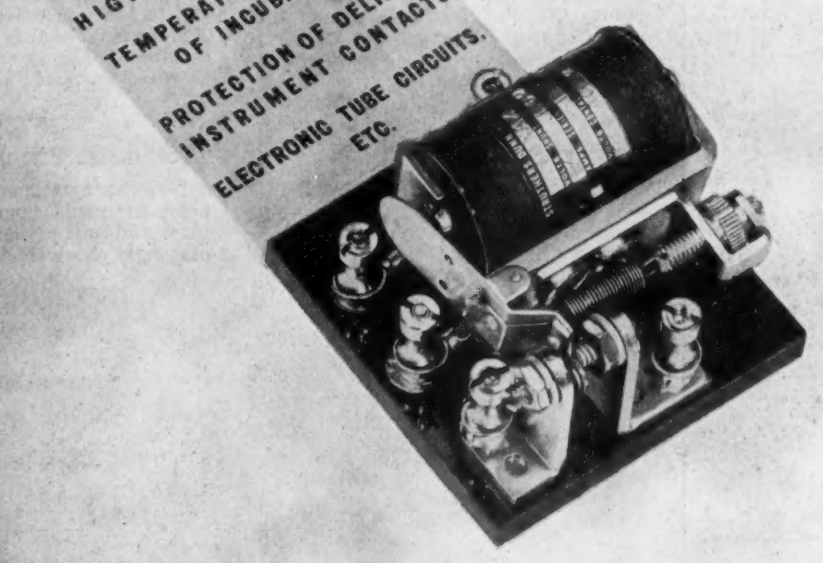
Please mention number 332 when filling out card

Sound Pressure Standard

New "Model BM-101 Hydrophone," primarily designed for use as a standard for underwater sound pressure measurements, can also be used as a



standard microphone for making acoustic measurements in air. Frequency range in water is from 100 cycles to 100 kc. and in air from 100 cycles to 20 kc. Unit consists of a sound pick-up head connected to a preamplifier by 5-conductor shielded cable with one internal conductor separately shielded. Sound pick-up head consists of a crystal assembly surrounded by castor oil and enclosed in a rubber housing. Ab-



SENSITIVE LOW-POWER RELAYS in a newly improved design

FOR USE ON AC AND DC

Engineering superiority in every mechanical and electrical detail makes Struthers-Dunn Type 112 Relays far and away "tops" for sensitivity and durability for low-power operation on the order of a few milliwatts • A "fool-proof" micrometer adjustment assures exceptionally reliable setting of the contact spring • All parts are of low-inertia, quick-acting design • Contacts are easy to adjust and stay "put" once adjusted • Coils are well insulated and vacuum impregnated • These new relays are built throughout for easier installation, higher sensitivity, longer life • Available in single-pole double-throw and double-pole double-throw contact combinations.

Write for Data Bulletin 112.

S-D
5,327 RELAY TYPES

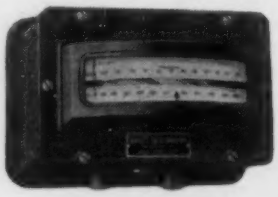
STRUTHERS-DUNN

STRUTHERS-DUNN, Inc., 150 N. 13th St., Phila. 7, Pa.

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

Wall-Type
INDICATOR PYROMETER

A PRODUCT OF 40 YEARS OF RESEARCH



Model W-1
Switchboard Indicator

Unskilled help may handle this direct-deflection instrument, which needs no manual adjustment. Designed for numerous ranges of temperature, both F. and C.

Write for descriptive Bulletin 400

Charles Engelhard, Inc.
233 N.J.R.R. Ave. Newark 5, N. J.

CLEANS
FINE PARTS
without
DISMANTLING
INSTRUMENTS!

☆

Eng-Sol Unit for Bench Installation

If you have a difficult or costly cleaning problem it will pay you to write for our bulletin "Precision Cleaning" completely describing the Eng-Sol high-velocity compressed air method of instrument cleaning.

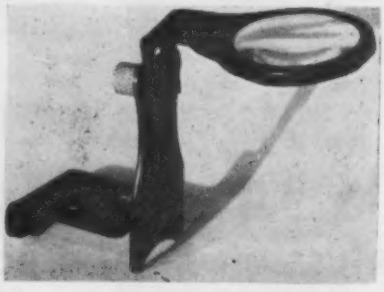
PASSAIC ANALYTICAL LABORATORIES, Inc.
228 Aycrigg Av. Passaic, N. J.

sence of mechanically-coupled elements contributes to extended frequency range. A removable screen protects rubber jacket from possible damage and also serves as an electrostatic shield. Preamplifier consists of two 1L4 type tubes mounted in sponge rubber inside a chassis which fits inside amplifier housing. Cable, water-tight gland and amplifier chassis are built as a unit which can be removed from amplifier housing to replace the tubes. When used as a microphone, unit is actually equivalent to a Rayleigh disk as far as diffraction errors are concerned, and yet it can be used with the same degree of facility as any other general-purpose microphone. Owing to small dimensions of pick-up, unit can be used as a probe for investigating sound pressure distribution inside a pipe carrying sound, or inside exponential horns and other sound-transmission systems. Instrument can be used to measure sound pressures in liquids contained within an enclosure, or to all practical purposes unenclosed. Static pressure limit, 15 lbs./in.^{2}; depth-in-liquid limit, 30 feet.—*Brush Development Co., 3321 Perkins Ave., Cleveland 14, Ohio.*

Please mention number 333 when filling out card

Adjustable Magnifier

New magnifying unit has 1½" diameter lens with full universal mounting, with maximum height adjustment of

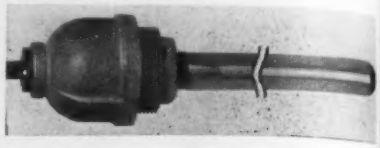


2". Base is heavy pressed steel. Maximum over-all height is 3½".—*Dayton Rogers Mfg. Co., Minneapolis 7, Minn.*

Please mention number 334 when filling out card

Thermocouple Assembly

New thermocouple assembly of improved design is supplied with standard No. 8 gage chromel-alumel or iron-constantan element; can be used with any make of pyrometer. Heavy seamless drawn ⅜" OD Inconel protecting tube fits thermocouple element closely for maximum sensitivity and speed of response, advantageous on automatic-control installations. Protecting tube is of unusually heavy wall thickness (0.147") and 80% nickel, 13% chromium ductile alloy eliminates porosity and brittleness. Terminal head is designed so that thermocouple can be quickly inspected without disconnecting leads or using a screw driver. There is no possibility of a wrong reconnection and no interruption of production. Thermocouple wires enter connecter without bending even when two-hole insulators are employed. Time-saving features are of advantage to large companies who assemble their own thermocouples. Thermocouple element is easily replaced by loosening two screws. New assemblies are recommended for all general heat treating service including neutral salt baths; except sulphurous atmospheres. Imme-



diate delivery on all standard lengths from 12" to 48" in multiples of 6"; and 60" to 144" inclusive in steps of 12".—*Arklay S. Richards Co., Inc., 52 Winchester St., Newton Highlands 61, Mass.*

Please mention number 335 when filling out card

Automatic Piston-ring Inspector

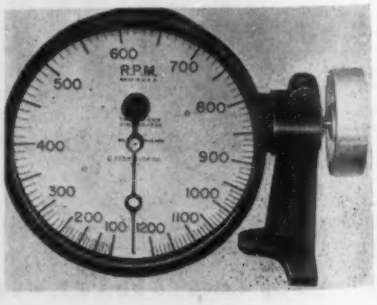
New automatic segregating instrument for rapid inspection of compression and oil piston rings will automatically check thickness to a tolerance

limit of 0.0005" and gap width to a tolerance of 0.007" or 0.010", and segregate rings at a rate of 2,400 per hour. After instrument has been set up, using piston rings of known minimum and maximum dimensions as masters, operator places rings to be inspected in three-finger stack holder with gaps arranged so that they fit rail on back finger. This insures all rings passing through various gaging stations in the same manner.—*The Sheffield Corp., Dayton 1, Ohio.*

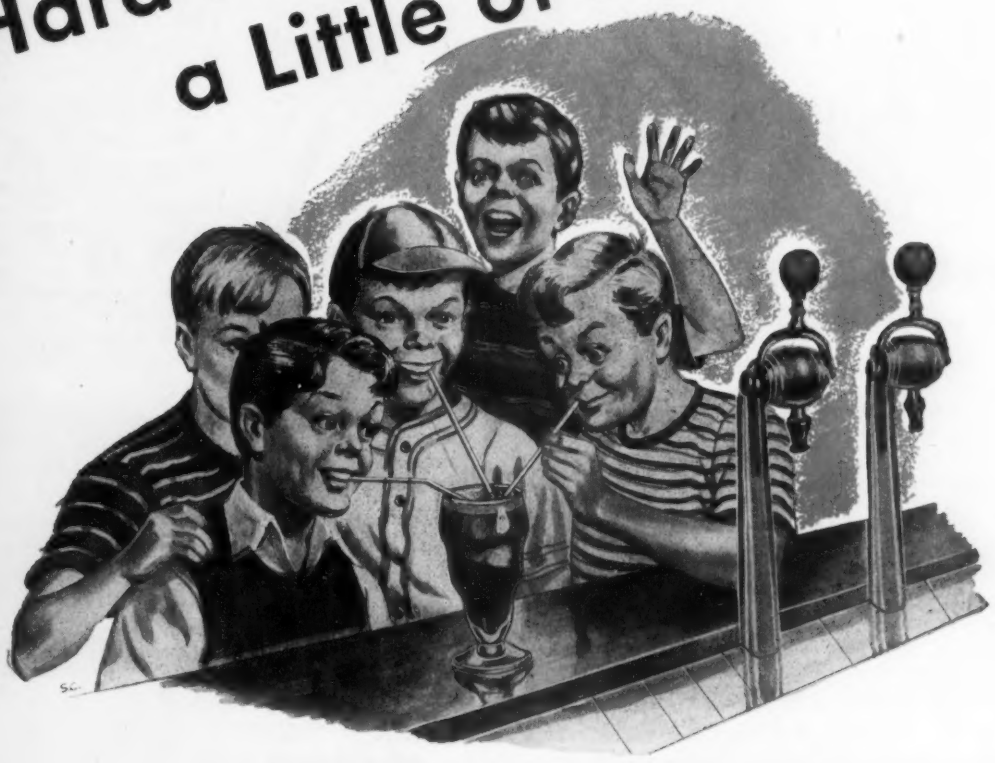
Please mention number 336 when filling out card

Stationary Centrifugal Tachometers

New "OZ Stationary Tachometers" embody a new construction of pendulum and indicating mechanism said to result in greatly enhanced perform-

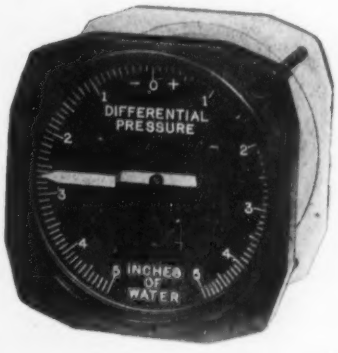


It's Hard to Divide a Little of Anything



Whether it's an ice-cream soda or pressure, the problem of measuring and dividing becomes more difficult as the quantity becomes smaller.

That's why W & T Low Pressure Gauges are specifically designed for precise low pressure measurement in any field — aircraft flight tests • automotive road tests • engine and carburetor testing • wind tunnel work • liquid level measurement • ventilation studies • gas burner installations and any other air or gas flow measurement.



That's why, too, you'll want all the advantages found in W & T Low Pressure Gauges — accuracy to one part in 300 • calibration for any desired range • portability • permanent and easy readibility • practical elimination of position error and effect of acceleration and gravity • compact and sturdy construction • expanded scale if desired • elimination of liquid level checking and possibility of contamination as encountered in liquid column manometers. Write today for Technical Publication 268.

A-62

WALLACE & TIERNAN PRODUCTS, INC.

BELLEVILLE 9 NEW JERSEY

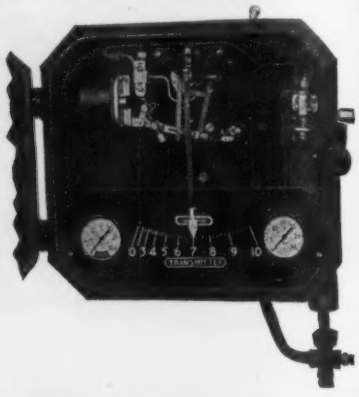
GENERAL ELECTRIC
REGULATED POWER SUPPLY
180-300 volts Type PS-2
For a simple, efficient, economical power supply to replace messy, space-consuming, expensive batteries install a modern G-E Regulated Power Supply. Extremely useful where d-c power is required to operate electronic devices in research or industry. Provides a stable d-c voltage regardless of moderately large or rapid changes in the a-c supply voltage. Other regulated power supplies available in various ranges. Write today: Electronics Department, General Electric Company, Syracuse 1, N. Y.
GENERAL ELECTRIC
165 #2

ance: "Free running to an almost unbelievable degree. A thread will drive the tachometer." Accuracy guarantee of new models is 0.5% in either direction of rotation. They are adapted not only for high speeds but extremely low speeds, even inches or feet per minute. Every tachometer is hand-graduated.—*O. Zernickow Co., 15 Park Row, New York 7, N. Y.*

Please mention number 337 when filling out card

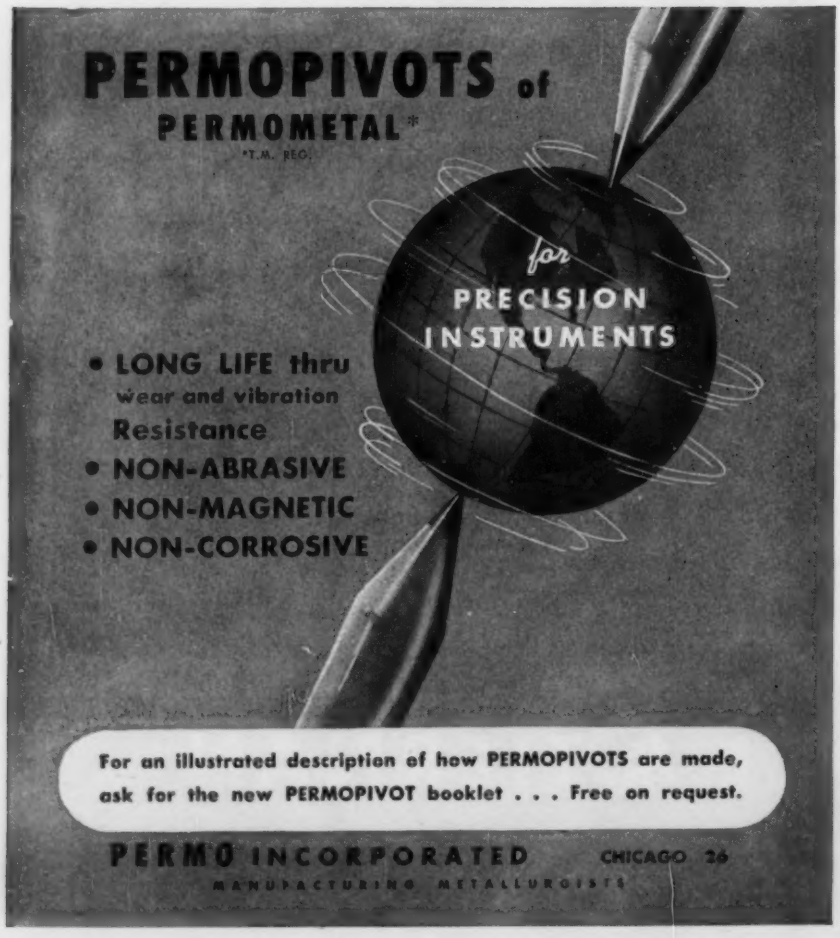
Pneumatic Transmitters

New "226R Series" pneumatic transmitters are said to provide a practical and economical means of pneumatically transmitting, from point of measurement to a central control panel, such process variables as temperature, pressure, rate of flow and liquid level. Among features are a minimum of moving parts and an improved baffle-and-nozzle assembly. New transmitters are factory-calibrated to accuracies within



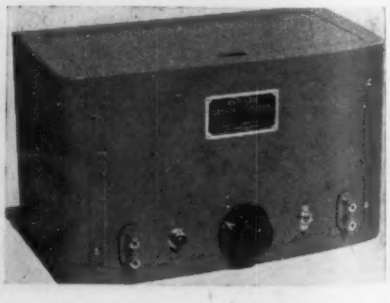
0.5% of scale range, assuring straight-line relations between pen or pointer movement and output air pressure throughout range. Standard range is 3 to 18 lbs./in.^{2}. Other available ranges are 2 to 14 and 2 to 15 lbs./in.^{2}. Only two micrometer screw adjustments are required: one for establishing range of instrument; the other for zero setting. Relay air valve is the one used in all "100 Series Fulscope Controllers." New transmitters (indicating or recording) are available for single or double duty; also as single-duty transmitter-controllers, containing any of the five standard forms of "Fulscope" control action.—*Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.*

Please mention number 338 when filling out card



Decade Amplifier

New "Model 102A Kaylab Decade Amplifier" is said to have higher gain and more power output than any previously available. Instrument has an out-

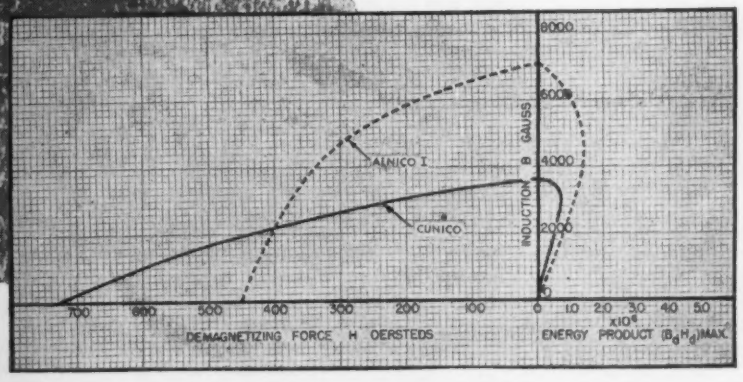


Machineable CUNICO

GENERATOR ROTORS CAN BE OPERATED SAFELY AT *125,000 RPM*

Cunico is the newest addition to the Arnold high quality permanent magnet line. It is a copper nickel cobalt alloy which has very high coercive force. Ductile, machineable and malleable, Cunico can be fabricated into a wide variety of simple and complex designs. Drawing, cutting, machining, punching and screw machine operations are practical.

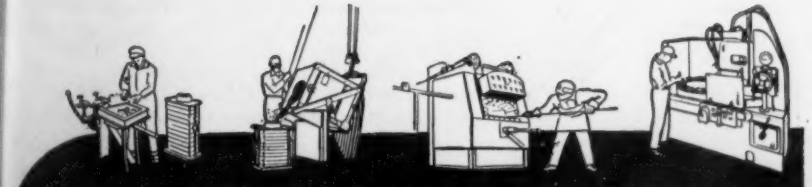
Cunico can be magnetized in any direction, and is most efficient where a large cross section is available to produce sufficient total flux. Generator rotors are a typical application. A relatively short length is required to maintain the flux because of its high coercive force.



CUNICO CAN BE PRODUCED IN THE FOLLOWING SHAPES AND APPROXIMATE SIZES:

BARS—¼" to 1" square
STRIPS—2" maximum width x .015" to .312" thickness
RODS—¼" to 1" in diameter
WIRE—No. 2 to No. 24 AWG sizes
CASTINGS—Maximum section 1" thick

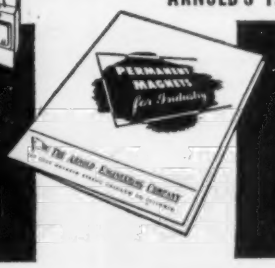
Write today for details.



THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the manufacture of ALNICO PERMANENT MAGNETS

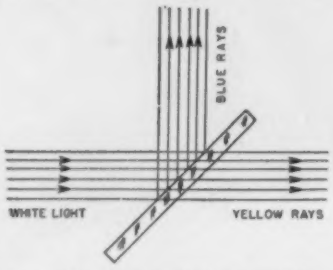


ARNOLD'S TECHNICAL BULLETIN

"Permanent Magnets for Industry" suggests many ways in which the war-born improvements in permanent magnets can be most valuable to you. Send for it!

FS MULTI-LAYER INTERFERENCE FILMS

Dichroic & Achromatic Beam Splitters



Chromatic Spectral Selection Effect; a certain portion of the spectrum is reflected, the remainder transmitted.

Achromatic Spectral Selection Effect; the incident light is split into two beams, one reflected, one transmitted, each beam retaining the spectral properties of the original incident beam.

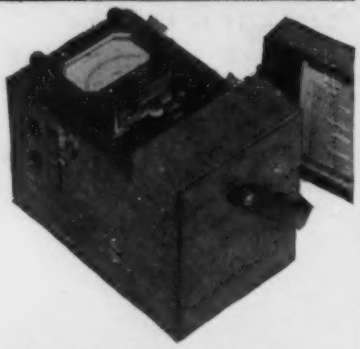
Transmission or reflection peaks as high as 85 to 90% but the spectral bands are relatively broad.

Submit your problems and ask for bulletin MI-318 giving graphs of standard types now available.

FISH-SCHURMAN CORPORATION
230 East 45th St., New York 17, N. Y.

Fish-Schurman

New... CRANKLESS MODEL C-2 MEGOHMER INSULATION TESTER



Test Potential to 600 Volts DC. Ranges to 1000 megohms with two or three additional ohm ranges in each instrument. Long mirror scales, hand drawn, individually calibrated, with more scale divisions for superior readability and split hair accuracy. Automatically decreasing test potential protects equipment of low resistance value.

Truly a Precision Instrument
WRITE FOR BULLETIN 445

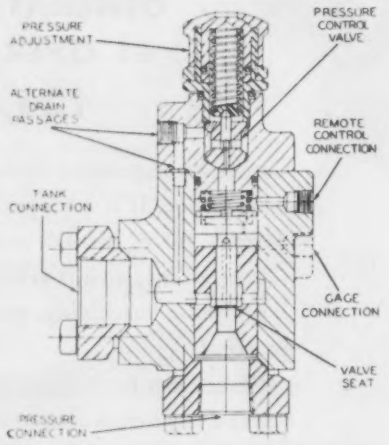
HERMAN H. Sticht COMPANY, INC.
NEW YORK N. Y.

put impedance of 25 ohms and is used as a pre-amplifier for copper-oxide type voltmeters as well as for vacuum-tube voltmeters. It will deliver up to 50 volts at 10 ma. RMS. It incorporates negative feedback in addition to a fully regulated power supply and is flat within 1 db from below 10 cycles to 1 Mc. Amplification factors are × 100, × 1000 and × 10,000 on its three ranges. — *Kalbfell Laboratories, 1076 Morena Blvd., San Diego 10, Calif.*

Please mention number 339 when filling out card

Extreme-pressure Relief Valve

New 5000-lb./in.² relief valve is said to eliminate disadvantages of previous designs. Squealing and chatter



are said to be completely eliminated. Instantaneous action (preventing objectionable pressure peaks), accurate maintenance of pressure setting, and perfect hydraulic balance are claimed. Provision is made for remote control. —*Superdraulic Corp., Dearborn, Mich.*

Please mention number 340 when filling out card

Portable Hardness Tester

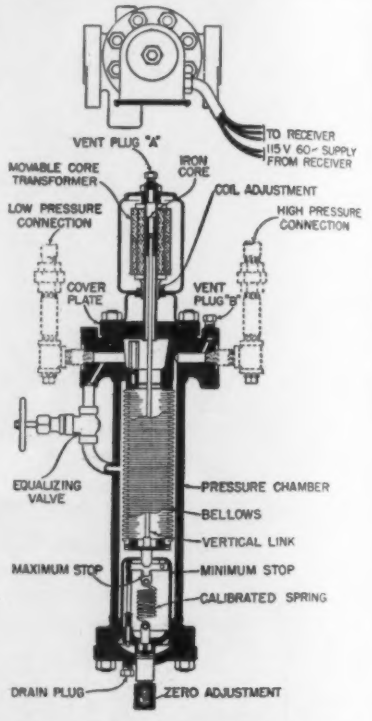
New "Ames Hardness Tester" is a portable (2-lb.) instrument employing diamond-point penetrator for Rockwell

"C" scale tests and a ball-point penetrator for "B" scale. Pressure applied by screw causes C-shaped frame to deflect, thereby moving pointer to dial marking for standard loads. Penetration is then read on barrel dial which is graduated in "B" and "C" scales. Throat capacity, 1". Accessories include a V-shaped anvil, two test blocks and Brinell conversion chart.—*Ames Precision Machine Works, Waltham 54, Mass.*

Please mention number 341 when filling out card

Superheater Protection

New "Superheater Protective Device" consists of a transmitter (illustrated) connected electrically to a



"Bailey Electronic Indicator." Transmitter is connected to superheater inlet and outlet headers to measure pressure drop and transmits this measurement to indicator. When steam flow approaches a predetermined minimum, a contact in the indicator flashes a red signal warning firemen to take necessary steps to save superheater from damage. System may also include a high-temperature warning device by addition of a resistance element installed at superheater outlet and connected electrically to two-dial "Bailey Electronic Indicator." When steam temperature at superheater outlet becomes abnormally high, system sounds a warning horn.—*Bailey Meter Co., 1059 Ivanhoe Road, Cleveland 10, Ohio.*

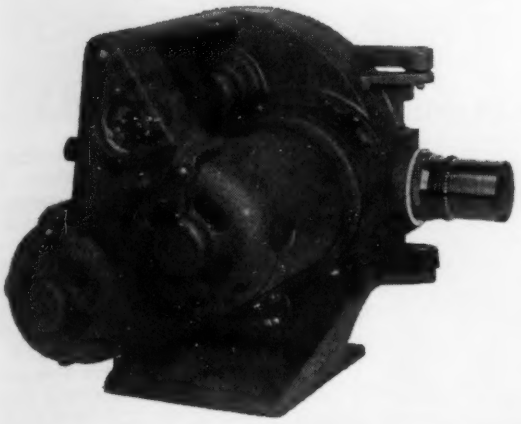
Please mention number 342 when filling out card

Vacuum-tube Voltmeter

New vacuum-tube voltmeter is maker's first "Laboratory Kit" (sold unassembled and priced at only a fraction of the cost but said to be fully comparable to the finest obtainable laboratory VTVM). Among features: generous oversizing of all components; many parts designed and manufac-

NEW Aid for Industry

in research, design engineering, and testing



Western Electric FASTAX CAMERA

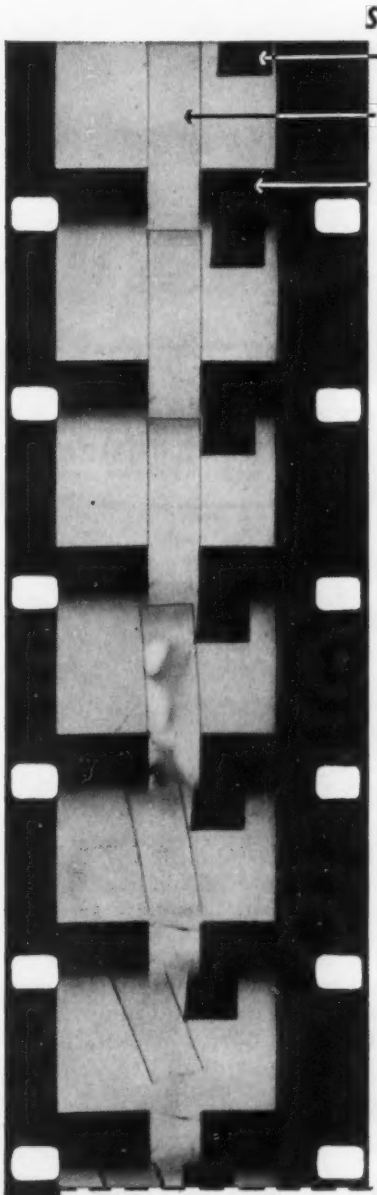
- World's fastest <u>portable</u> motion picture camera
- Lays bare secrets of rapidly moving parts
- Takes black-and-white or color

The new Fastax Camera photographs the action of high speed machinery or other short-duration phenomena—indoors or outdoors—at speeds up to 8000 frames per second with the 8 mm model—up to 4000 per second with the 16 mm model. When such pictures are projected on the screen at the rate of 16 per second—a "time magnification" as high as 500 to 1—they lay bare the innermost secrets of fast-moving parts.

In research and design engineering of machine tools, textile machinery, aviation, automotive and many other types of products having moving parts, the Fastax can quickly show up frailties and lead to better design.

It is invaluable, too, in testing materials and finished products.

Designed by Bell Telephone Laboratories, the Fastax Camera solved many important wartime problems. It is now available to help you. For complete information, fill in and mail the coupon, or contact your local representative of the Graybar Electric Co.



SEE how it works in materials testing

Here the Fastax Camera shows you just what happens when an unnotched plastic test specimen 2½" x ½" x ¼" is broken in an Izod impact testing machine. Note the stress patterns at the moment of impact shown in the fourth frame from the top.

These *unretouched* enlargements are from a 16 mm Kodachrome film taken with polarized light at a speed of 4000 frames per second.

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Graybar Electric Company, Dept. I 22
420 Lexington Ave., New York 17, N. Y.

Please send me full information about Western Electric Fastax Cameras.

Name .....

Company .....

Address .....

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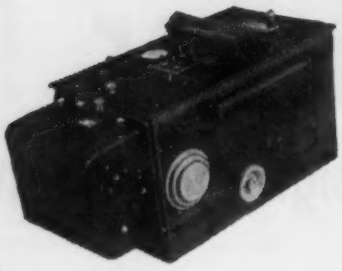
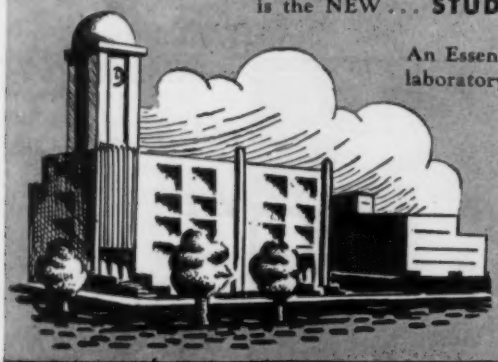
TODAY'S SCHOOLS...

must train for TOMORROW — a challenge intensified by the accelerating pace of scientific and engineering advance.



Specially designed to meet the needs of modern education, is the NEW . . . **TYPE S-14 STUDENT'S OSCILLOGRAPH**



An Essential part of the modern college laboratory:

- Accuracy, for the critical researcher
- Simplicity, for the undergraduate student
- 6 to 12 channels, precision components

WRITE FOR TECHNICAL BULLETIN SP-183B

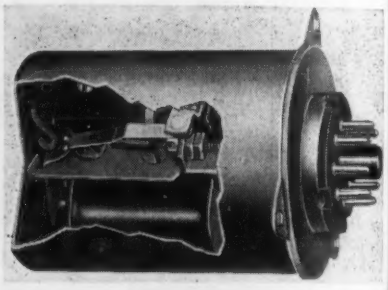
Hathaway INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

tured specifically for this instrument; close tolerances; laced cables; fully-drilled chassis and sub-assemblies; aged and selected tubes and profusely-illustrated instructions. Only a screw driver and soldering iron are required to assemble and wire entire unit; job can be done in a few hours' time.—*Frederic D. Schottland, 104-18 Metropolitan Ave., Forest Hills, N. Y.*

Please mention number 343 when filling out card

Sealed Plug-in Relay

New "Bulletin 108 Sensitive Relay" is of plug-in type mounted on standard octal base and enclosed in hermetically-sealed cylindrical metal can. Relay is



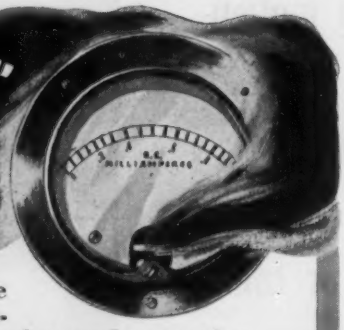
provided with a normally-open single-pole contact having contact ratings of 2 amperes 24 volts a.c. or d.c., 0.75 amperes 125 volts d.c. and 2 amperes 125 volts a.c. (A-c. ratings are for non-inductive loads at commercial frequencies.) Average coil consumption is 0.056 watts. Can dimensions 2" dia. by $2\frac{1}{16}$" high.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Please mention number 344 when filling out card

Photoelectric Flame-failure Safeguard

New "Fireye Photoelectric Flame Failure Safeguard" protects against hazard of explosion caused by flame failure in industrial oil burner installations. Equipment consists of "Photoelectric Scanner Type 45PH5" for monitoring main oil burner flame and "Programming Control Type 24PJ8" for programming oil pump, oil valve, and ignition system. "Flame Rod Type 45JP1" may be added if desired to monitor the gas pilot flame as well. Scanner is said to be readily installed on burner plate either at time of assembly of original burner equipment or upon installation in the field. Since

"POWER TO BURN"



Littelfuse precision-built fuses are so inexpensive that every manufacturer can effectively protect his product and reputation at relatively small cost. Complete range of types and sizes for instruments, small motors, radio and electronic circuits, automobile, aircraft and marine instruments, and all types of electrical equipment. For complete information on these and other Littelfuse quality products, send for Catalog No. 9 . . . just off the press.

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Accuracy to the Microsecond.....!

NEW AND IMPROVED DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

IMPROVEMENTS

- Beam blanking over a range of 30 cps to 5 mc by automatically applying approximately 100 volts potential to the grid of the cathode-ray tube.
- Sweep linearity within approximately 10% over the entire range from 15 cps to 150 kc, and on driven sweep.
- These special improvements, plus the already established features of the Du Mont Type 248, assure you of the continuing perfection which makes possible the slogan . . . Accuracy to the Microsecond—Improved!

WITH NEW TIME BASE GENERATOR AND BEAM BLANKING CIRCUITS

SALIENT FEATURES

- Wide band Y-axis amplifier; usable to 10 mc.
- 4,000 volts accelerating potential for Type 248, and 10,000 volts for Type 248-A
- Extremely flexible time-base generator
- Observation of entire waveshape of short duration
- Timing oscillator for quantitative analysis
- Use as a synchroscope
- Convenient mechanical design with separate power supply

SPECIAL NOTE: This instrument is also available as Type 248-A which utilizes the Type 5RP multiband high-voltage cathode-ray tube in lieu of the Type 5JP normally supplied. The required high voltage is supplied by the Type 263-A 10 KV power supply.

Present owners of Du Mont Type 248 may have their instruments modified into Type 248-A design if they so desire. This modification makes possible the photography and visual observation of single transients which have extremely high writing rates and which were hitherto invisible.

Write for literature.

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DUMONT *Precision Electronics & Television*

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RAWSON TWIN MULTIMETER

Type 5012 Accuracy ½ of 1% DC
Size 12"x 8"x 6"

A Combination AC. Multimeter and DC Multimeter

Range of Measurements

DC 1 Microampere to 1 Ampere.
20 Microvolts to 1000 Volts.

AC (thermocouple type)
2 Milliamperes to 3 Amperes.
60 Millivolts to 1000 Volts.

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WE ALSO SUPPLY
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THERMOCOUPLE AC METERS
MULTIMETERS
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Special apparatus built to order

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TESTERS
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CORDAGE
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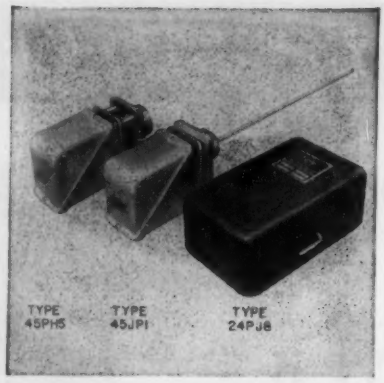
FLAT MATERIALS

PAPER FOLDING ENDURANCE TESTER
BURSTING TESTER
MICROMETERS (POCKET and DESK)
PAPER BASIS WEIGHT SCALES
CORDAGE SCALES
ALUMINUM FOIL SCALES
COMPUTING SCALES
RUBBER ABRASION TESTER
DEAD WEIGHT PRESSURE GAUGE TESTER
TACHOMETERS INDICATING and RECORDING
MERCURY COLUMN GAUGES

AMTHOR
TESTING INSTRUMENT CO. INC.
48 Van Sinderen Ave., Brooklyn, N. Y.



it contains both phototube and amplifier tube, no special shielded cable is required between scanner and programming control. System is designed to withstand 125°F. ambient temperature and is impervious to humidity. Programming control provides oil-valve delay and post-ignition period settings in seconds. Timing is by synchronous motor. Relay contacts are capable of handling directly a 1-hp. pump motor. *—Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Please mention number 345 when filling out card

Air Pressure Regulator

New air pressure regulator is adjustable to function in systems operating at pressures from 10 to 150 lbs./in.^{2}, comes with a pressure gage. A number of these regulators can be used in a system, one for air-operated unit, because of reduced wear and tear on compressor and reduced air costs, better control, etc.—*A. Schrader's Son, Div. of Scovill Mfg. Co., Inc., Brooklyn 17, N. Y.*

Please mention number 346 when filling out card

Automatic Inspector-classifier for Small Parts

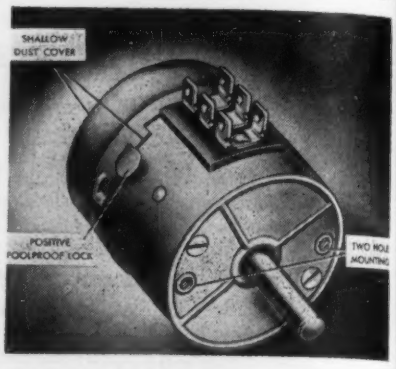
New automatic inspection system for small parts (company's first offering to private industry after 25 years developing and manufacturing instruments for the U. S. Navy exclusively) is an electronic light-indicating comparator with automatic classification of parts up to 1½" sphere maximum size. This equipment inspects, counts and sorts parts and places them in good and rejected groups. In conjunction with a variety of components likewise

furnished by this company, system is said to offer inspection stations to meet the needs of every type of industry; and to be adaptable for both manual and hopper feeds with no thought or skill required. Features: broad range of adjustable tolerances; speeds up to 7,000 pieces per hour; changeover from one part to another or from one dimension to another in a matter of minutes. *—Arma Corp., Brooklyn, N. Y.*

Please mention number 347 when filling out card

Attenuators

New type of mechanical construction for attenuators has improved features including: (1) non-ferrous can; (2) totally-shielded dust-proof housing;



(3) two-piece can with foolproof lock whereby dust cover can readily be removed with one hand; (4) all moisture-absorbing parts eliminated; (5) ground lug on can supplied if required. Two-hole mounting is standard but single-hole mounting available. Dimensions of new unit interchangeable with preceding models.—*The Daven Co., 191 Central Avenue, Newark, N. J.*

Please mention number 348 when filling out card

Wire Recorders for Sound

New magnetic wire recorders utilize stainless steel wire without any mechanical contact, make possible 10,000 play-backs. Undersigned company, which manufactured wire recorders for

air, sea and land service during the war, announces that it is now in quantity production of two perfected business models, one for office, the other a portable model for two-way air communication, for outside use by executives, reporters, etc.—*Peirce Wire Recorder Corp., 1328 Sherman Ave., Evanston, Illinois.*

Please mention number 349 when filling out card

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

On Starting an Instrument Department

Dear Mr. K——: Your inquiry of February 8th on starting an instrument department was the latest of many of its kind to which—of necessity—only brief replies were sent. This time, however, I have spent a few hours putting down data and compiling a list of references—not only for you but for others who will read this in our next issue, because this letter will be run as the March editorial.

Under your name the title "Secretary-Treasurer" is typed, but our Circulation Department informs me that you have your *Instruments* mailed to your home address and that you are an old subscriber, so I have reason to feel certain that you (and perhaps others in the top management of your company) do not need to be convinced of the value of an Instrument Department.

Up to now, someone in this office replied briefly, giving as the only reference the book "Fundamentals of Instrumentation," of which the last chapter is a compendium of seven sections by seven authors, under the general title "The Plant Instrument Department — Its Organization and Equipment." This book has been out of print for several years and is no longer to be found in all technical libraries — not even in some of the big ones, whose librarians ordered replacements after our supply ran out. Even our last office copy disappeared a couple of years ago. Therefore the procurement of this book —even on loan—is becoming more and more difficult, especially for young companies like yours and others in the aviation industry. We are at work on a new edition with thorough treatments of Instrument Department problems, but you want information promptly. Hence the long list of articles appended to this letter, in addition to the letter itself.

Calibration, etc.

You will find many lists in the appended bibliography but I cannot give you one single list. The reason is that there does not exist a list of reference standards, calibrating devices, and other equipment suitable for *any* Instrument Department and at the same time within the budget of an "average small" Instrument Department. Moreover, the question what is an "average small" Instrument Department cannot be answered exactly because no two departments are alike. Yours, for example, is closer to the air transport industry than to, say, the textile industry. I have often "stuck out my neck," however, in asserting that *there is one universal principle* which, if observed, will enable any department to determine its minimum requirements. It is simply the principle that each working instrument should be checked periodically against a "standard," which "standard" need not be an elaborate and expensive National Bureau of Standards instrument or apparatus, but only an instrument *more accurate than the working instruments by one order of magnitude*, or, as the common expression goes, by "one more decimal."

In other words, if you have a number of indicating and recording thermometers all desired to be accurate to one degree Fahrenheit and if the temperatures they measure do not exceed the range of 32°F. to 600°F., then all you need to check them is four or five laboratory-grade thermometers accurate to 0.1°F. and several small home-made baths or chambers in which to immerse the bulbs of a working thermometer and of a standard thermometer. These baths or chambers need not be expensive precisely-adjustable constant-temperature baths such as those in research laboratories, but can be simple and inexpensive. The essential is not that the temperature should be controllable or adjustable to a small fraction of a degree but simply that the temperature remain constant while the readings of the working thermometers are being compared with the readings of the certified thermometers. For this kind of constancy the principal requirements of a bath (water, oil or salt) are ample capacity, stirring and insulation. In addition to a bath, a steam chamber can be easily contrived from a four-foot length of 6″ or 8″ pipe.

For calibrating ordinary working pyrometers of the thermoelectric type, likewise, a portable potentiometer, one or two certified thermocouples, a Thermos flask for ice-point reference, and one small laboratory oven should suffice—but be sure to follow the instructions accompanying the portable potentiometer.

For calibrating pressure gages, *including the differential manometers of most flowmeters*, two or three simple mercury and water columns, plus a dead-weight tester or an "inspector's gage" for the higher pressures, will suffice. Bear in mind that liquid columns are "primary" standards only when properly measured.

Working tachometers can easily be checked by any of several readily-available chronometric tachometers or by using a narrow-range frequency meter in conjunction with a small a-c. generator (or one of various "benches" or "stands" specially made for the air transport industry — with which you are already familiar).

For calibrating CO and CO_2 working instruments there are various styles of laboratory apparatus — some of them portable but remarkably accurate when properly used.

And so on for other basic classes of measurements, the result being not a "laboratory" but simply a group of independent calibration benches.

The next stage usually consists in the acquisition of standards of length, mass, etc.: gage blocks, micrometers, a laboratory balance, a Wheatstone or Mueller bridge, a microscope, a mercurial barometer, etc. With such equipment at hand, in addition to the items already mentioned, you have a laboratory section, or standards section, within the Department—and it should be operated by at least a junior physicist, unless it is under the direct supervision of a Department Head who is himself either a physicist or an engineer possessing the requisite special knowledge, preferably gained by experience.

Maintenance, etc.

You request a list of equipment for maintaining and servicing your plant instruments of "various makes." For bare maintenance, a small new Instrument Department usually starts with hand tools only. If the instrument manufacturers' printed instructions are faithfully observed, a good assortment of pocket tools will be quite sufficient to keep them in good condition in *your* plant. I state this without hesitation because I am sure that you have employed a number of ex-service men who had been given Aircraft Instrument Technician training. These men, under proper supervision, can maintain your industrial instruments in good condition — if these instruments are not abused in your heat-treating department, machine shops, power plant, etc. (By the way, are the heads of your operating departments instrument-

minded? Also, are there instrument-trained ex-service men in *all* of these departments?)

"Servicing" is quite a flexible term. To most Instrumenticians, however, it covers much more than maintenance, for it includes field and test-stand adjustments (even critical adjustments) and some repairs, but it does not include the advanced or major repairing which involves making parts, refilling tube systems, etc. I am at a loss to furnish you the list of equipment you request. Being an old *Instruments* subscriber, you know that skill and experience are much more important than special equipment. Although you do not list electrical indicating instruments and give me the impression that you will send them back to the factory for servicing, I recommend Spencer's "Maintenance and Servicing of Electrical Instruments" published by our company: the new 272-page second edition is well worth its two-dollar price.

When your maintenance and servicing equipment overflows a tool kit and includes a small lathe, a drill press, a grinder, a welding outfit, etc.—when it requires benches—this expansion will mark the second stage—just as with your calibrating facilities. Then, the Department will be divided into a *laboratory* and a *shop*, perhaps still in the same room but sharply separated functionally. This functional division is important. Moreover, as the Department grows, there will be a third function, namely, *office work*, keeping records of all the working instruments in your plant and providing for their calibration at regular intervals.

I must repeat, however, that no two Instrument Departments are alike, even when they are new and small—especially when they are new and small, for then it usually is one man's personality, his relations with top management, his ability to "sell" his Department, and other intangible factors, that determine the initial investment and the plans for future expansion.

Bibliography

You will find equipment lists—and much other useful information—in the numerous articles we published on plant Instrument Departments (and Testing Departments, etc.). Herewith is a partial list: In the last column, "L" indicates that *lists* are included; "T" indicates that *training* of personnel is discussed; "O" indicates that departmental *organization* is discussed.

If your *Instruments* file does not go back to 1932 you can look up the older articles the next time you are in a town where there is a library that has *Instruments* files or you can order photostats or microfilms. A word about the articles by the undersigned in 1936 and 1937: these are some of the articles in a series entitled "*Instruments* Readers at Work" and, as you progress in building up your Department, you will do well to correspond directly with some of these men, also with some of the other large-company Instrument Department heads who have written articles cited in my list. I am sure that each one has a collection of mimeographed or printed matter pertaining to his Department, from which he can conveniently spare some for outside distribution. They all are fine men—helpful and considerate as well as top-flight Instrumenticians.

Cordially yours,
M. F. Behar, *Editor*

Year	*Month*	*Author*	*Co. whose dep't is described*	*Spec.*
1932	Feb.	R. W. Brown	Firestone T & R Co.	O&T
1935	Nov.	G. P. Bosomworth	Firestone T & R Co.	T
1936	Jan.	M. F. Behar	Westinghouse (plant)	L
	Feb.	M. F. Behar	Bantam Ball Bearing Co.	L
	Mar.	M. F. Behar	Dow Chemical Co. (Phys. Lab.)	L
	Apr.	M. F. Behar	Pittsburgh Plate Glass Co.	L
	Apr.	R. C. Kennan	Brown Instr. Co. (Training Dep't)	T
	May	M. F. Behar	Gulf Ref. Co. (Neville Id. Ref.)	L
	June	M. F. Behar	Pittsburgh Testing Labs.	L
	July	M. F. Behar	Navy Yard, Wash'n, D. C.	L
	Aug.	M. F. Behar	H. J. Heinz Co.	L
	Sep.	M. F. Behar	Airco Lab., Jersey City	L
	Oct.	M. F. Behar	Duquesne Works, C.-I. Steel	L
	Nov.	M. F. Behar	Driver-Harris Co. (Quality Control)	L
	Dec.	M. F. Behar	Nat'l Radiator Corp. (Research Dep't)	L
	Dec.	A. C. Moon	Atlantic Ref. Co. (Phila. Ref.)	O
1937	Jan.	A. C. Moon	Atlantic Ref. Co. (Phila. Ref.)	T
	Jan.	M. F. Behar	Westinghouse (Labs only)	L
	Apr.	M. F. Behar	Good Housekeeping Inst. (Lab)	
	May	Carlos De Zafro	N. Y. Univ. Gage Lab.	L
	July	M. F. Behar	Bristol-Myers Co.	L
	Aug.	Walton Forstall	Phila. Gas Works Co.	O
	Aug.	M. F. Behar	W. B. Driver Co.	L
	Dec.	M. F. Behar	Pacific G. & Elec. (Lab)	L
1938	Mar.	W. G. Egnor	G-E (Calib'n Equipm't)	
	Apr.	W. R. Gilbert	Weston (Calib'n Equipm't)	
	May	R. L. Strode	G-E (Motor Testing)	L
	May-Sep.	W. W. Dulmage	Ford plant (five articles)	L
1939	Apr.	C. B. Cochran	Charleston Trade School	T
	Dec.	Fred Hunter	United Air Lines (base)	
1940	Jan.	Ralph Rand	Texas Co., Casper, Wyo.	O
	Jan.	F. F. McClure	Ohio Steel Co., Cleveland	
1941	Oct.	Carl Nisbet	Delta Airlines (base)	O
	Oct.	Morey Eggleston	Western Air Lines (base)	
	Oct.	Hugh Davis	TWA (base)	T
1942	Jan.	George L. Seavy	Boston Gas & Fuel	
	Mar.	Philip Ewald	ESMDT Course	T
	Apr.	Robert H. Burck	Am. Airlines (base)	T
	Apr.	Carl Nisbet	Delta Airlines (base)	T
	Apr.	W. P. Danke	TWA Instr't Dep't	O
	July	R. G. Ojers	Spartan Sch. Instr't Dep't	O
	Sep.	M. L. Clarke	Bell Labs Instr't Bureau	O
	Sep.	C. S. Gooch	Shelby Aero School	T
	Oct.	C. H. Smith	Chicago Aero School	T
	Dec.	W. J. Watkins	Am. Sch. of Aircraft Inst'ts	T
1943	Feb.	Elden G. Chapman	Spokane AAF Instr't Shops	T
	Apr., June, Nov.	R. A. Bowman	"Ideal" gage dep't equipment	L
	Oct.	Harry Gollob	Standardized courses	T
1944	Jan.	D. J. Bergman & G. G. Gallagher	Univ. Oil	O
	Jan.	G. P. Bosomworth	Firestone T & R	T
	Jan.	R. W. Cermak	Dow Chem. Co. (Instr't Dep't)	T
	Apr.	V. H. Hiermeir	(Typical Oil ref. instr't dep't)	O
	Nov.	J. W. Lankford	CAA Mechanics' Certif.	T
1945	Feb.	Mrs. M. M. Gilbert	Bell Lab. elec. instr't calib.	L
	Nov.	SPECIAL ISSUE on Instrumentation and the University but containing many industry discussions		O&T
1946	May	F. H. Trapnell	Eng'g Dep't, duPont	O
	Oct.	H. F. Moore	Std. Oil Co. of N. J.	O&L
	Oct.	H. C. Frost	Corn Products Ref. Co.	
	Nov.	J. W. Graeb	Canada's syn. rub. plant instr't dep't	O
	Dec.	Joseph Manuele	Westinghouse (Quality Control Dep't)	O
	Dec.	Roger L. Geer	Cornell Univ. Instr. Course	T
1947	Feb.	W. H. Fortney	Humble O & R Co. (Baytown Ref'y)	O&L
	(soon)	P. G. Exline	Gulf pilot plant Instr. Dep't	O&L

Temperature Instruments of the Future

By PAUL G. WEILLER, Consulting Engineer, New York City

VACUUM TUBES have been in existence for exactly forty years. Their application to communication has already cut a wide swath in peace and in war. Their applicability to industrial measurement and control instruments should have been obvious.

Yet we can safely say that only the surface has been scratched in industrial electronics. The appearance of vacuum tubes in our every-day life has been super-dramatic. Its shadow has eclipsed a wealth of less spectacular developments. A great number of these are still buried. They form a gold mine for the prospecting engineer and designer. The industrial use of some of the newest electronic circuits, for instance, has been very limited as yet.

True, induction heating has come of age and dielectric heating is growing up, but electronic amplifiers have only just made their appearance in the measurement and control devices made by the leading instrument companies.

We have some newer types of slow-speed motors, which obviate the need of clumsy reduction gears in instruments. Few of them have been incorporated as yet in standard designs.

Some use has been made of the latest solenoid designs, but their possibilities have been by no means exhausted.

New types of ceramics have found large-scale use in capacitors because of their high dielectric constant; other ceramics with remarkable electric properties still await wider applications.

The strip mills making continuous lengths of sheet steel available for body building have almost revolutionized the automobile business. Novel alloys and metals and old ones in heretofore unobtainable thicknesses, widths and lengths now await the genius of the designing engineer.

These are only a few of the most conspicuous examples from among the accumulated abundance of knowledge, skills, techniques and design elements available . . . and awaiting the designing engineer.

We have selected temperature instruments as the subject of our excursion into things of the future, because temperature instruments make up more than one-half of all instruments sold. Therefore they overshadow all other instruments in technical and economic importance.

Let us imagine ourselves at the drawing board, facing the task of designing the most advanced temperature instrument. Out of the design features available and not yet generally used, we will select the most promising ones and combine them into the temperature instrument of the future. If we do this in our mind, we can visualize its performance and appearance.

The Primary Element

Since the beginning of temperature measurements, the variety of primary elements has not increased very fast. The expansion of mercury is, of course, the oldest physical property used, and mercury-expansion thermometers still bulk large among these instruments. The expansion of solid metals, of gases and of volatile liquids was added some fifty or sixty years ago.

The thermocouple appeared at about the same time for the measurement of high temperatures. Still later, the resistance thermometer was placed on the market, but it never attained any great popularity except as a precision instrument for laboratory use.

For the temperature instrument of the future, we will select two new types of primary elements. A choice of new high-temperature-coefficient ceramics will provide us with a short-range high-sensitivity unit, while for wide ranges and lower sensitivity, ceramics or glasses coated very thinly with various metals will probably be found to be the most attractive.

The instrument will, of course, be an advanced resistance thermometer. The new units make higher sensitivity and, in some cases, even more stability available to the engineer.

While sensitivity and accuracy of the conventional type industrial thermometer is of the order of $\pm 1°$, it will be easy with the new type of unit to construct temperature indicators and controllers which will be operable within differences of $\pm 0.01°$ or less.

The new ceramics also seem to be extremely stable—probably more so than any of the older types of primary elements.

High-temperature-coefficient ceramics make available temperature coefficients up to 6% per degree centigrade. These compare with 0.36% for platinum resistance elements.

Furthermore, they can be produced of any desired resistance values. For work with electronic amplifiers we can make them to be about 100,000 or 200,000 ohms. Therefore, we can use from 25 to 50 volts of exciting a-c. potential, instead of the fraction of a volt or several volts employed on metal-wire resistance units.

The combination of high voltage and high temperature coefficient results in a signal voltage about a thousand times greater than that obtainable from the old-type units. We thereby eliminate one or two stages of amplification. The resultant reduction in cost is not particularly important. But the gain is stability, simplicity and ease of maintenance is very considerable.

While metal-coated ceramics or glasses have the same temperature coefficient as the corresponding metal wires, they are attractive because, owing to their higher resistance, they permit the use of higher voltages.

We have ample reason to believe that the accuracy of these units could be made to be very much better than that of all conventional units other than the platinum resistance thermometers.

Now, some readers may ask, what on earth is the use of measuring and controlling temperature with greater accuracy? I could cite a few cases where the advantage is quite definite.

There are for instance some industrial processes where the temperature cannot be permitted to rise beyond a certain ceiling without spoiling the product. On the other hand, reaction speed and yield increase with the reaction temperature.

With conventional instruments, the controlled temperature must be kept low enough to make sure that the ceiling will not be pierced by the overshooting of the control point. Increasing the sensitivity by a factor of 10 results in reducing the range between the lowest and highest temperature of the batch, also, by approximately a factor of 10. Consequently, the control point and, with it, the average process temperature, can be kept much closer to the ceiling without danger of spoilage.

I know of one case where the drying time of a product has been reduced from five days to three days by the installation of a *really* sensitive instrument, and the attendant increase of the drying-room temperature was only 12°.

The higher speed of response will operate in the same direction. The new elements can be made to have a very small mass. Therefore, the speed of response is higher than that of any other conventional temperature-sensitive element except a bare thermocouple.

Remote Control and Indication

Hardly any of the conventional instruments is convenient for remote indication and control over distances of more than fifty feet. It would be desirable to have temperature instruments

with performance entirely independent of the distance between primary element and recorder or controller.

Because of the high resistance of the new primary elements, several hundred feet of cable can be inserted between the bulb and the amplifier. Between the amplifier and the controller or recorder, if any, there could be several miles of wiring without affecting performance.

Pneumatic instruments have an appreciable time lag, if the controller-to-valve distance exceeds a few hundred feet. Electric transmission is, of course, instantaneous, regardless of distance, if some simple precautions are taken.

Multiple recording and indications at various points in the plant are also easily accomplished.

The Off-and-on Control

While any desired operational characteristics can be incorporated in our instruments of the future, some of them will undoubtedly be plain off-and-on controllers. Such a system will consist of the primary element, a connecting cable, an amplifier and a simple relay unit adapted to vacuum-tube operation.

Only one stage of amplification in addition to the output stage is necessary.

The prime relay is of the sensitive variety which, in turn, controls a medium-size relay. The contacts of the latter can handle up to 30 amperes.

Such a combination has been put through 50,000,000 operations without failure.

The bad reputation of relays is quite unwarranted. Relays can be made as reliable as steam engines, if their limitations are carefully determined.

In addition to greater sensitivity and a lower time constant, other desirable features can be incorporated into such an automatic controller. Up to three relays can be used in series, each one set for a different temperature.

There are various obvious uses for this arrangement. One of them is prevention of overshooting in a batch process. One of the relays can be used to switch off part of the fuel supply before the finer control temperature is reached. This, however, does not exhaust the designed flexibility of such a controller. If it is used in connection with an electropneumatic value operator, the output of the amplifier can be employed to operate the modulating value. In this way, the speed of correction can easily be made a function of the extent of deviation. In this way, we can obtain an advanced type of control with extremely simple means.

Indicator-recorder

Temperature instruments started their career as hand-made fine instruments. Later on, when they were being produced in larger quantities, they were designed so that most of the parts could be made on a punch press. Most of the mechanism now has not a little of an alarm-clock appearance. That does not seem to interfere with the efficiency of their performance—when they are in good order. As they consist of comparatively flimsy parts and the power available to drive the mechanisms is never ample, they require an undue amount of maintenance to prevent them from sticking occasionally, and otherwise getting out of order. Maintenance, repair and service require trained instrument men.

Would it not be worth while to build an advanced instrument with the appearance of a machine where no shaft is smaller than ¼"? Such instrument machines could then be maintained by the same skilled mechanic who takes care of other high-grade equipment. It would not be necessary to use instrument specialists.

This seems a large bill to fill, but the advances in engineering applicable to instruments have been so considerable that all these requirements can be complied with quite easily by the Instrument of the Future.

There are a number of ways of adding an indicator to the thermometer of the future. The simplest and most effective one consists of mounting a variable resistor so as to make up two arms of the bridge directly on the pointer shaft. In its simplest form, the relay of our off-and-on controller will start, stop and reverse the driving motor, and with it the pointer shaft. If there is any demand for super sensitivity, say 0.01° or better, this can be readily accomplished.

The relay is replaced by a 0-to-1 milliammeter. The tip of the pointer is provided with a minute contact which operates against two stationary contacts. With an associated electronic relay, the movement of the milliammeter pointer will then control the pointer motor.

In spite of everything said to the contrary, it is perfectly practical to operate in this fashion and, in fact, there are several ways of utilizing the contact between a pointer and stationary contacts, even at contact pressures of a small fraction of a milligram. Such an arrangement, if properly designed, will go through 30 to 50 million operations without the slightest trouble.

Let us follow the details of this instrument, starting from the outside, then going into further details of its mechanism. In keeping with recent trends, the instrument will probably have a 10" circular chart. The scale surrounding the chart is blocked in heavy lines and figures.

We are striving for a visibility range of about 200 feet. The scale might be illuminated from the rear, to increase the visibility if the instrument is located in some dark place. A set of red, white and green signal lights might indicate whether the temperature is within the desired range or not. With this instrument, it is quite easy to provide for automatic range switching.

Suppose we use the instrument to indicate the temperature of a batch process, the control point being set at 250°, for instance. During the heating-up period, the instrument will operate under a 500° full scale range. At 220°, the range will be switched automatically to a 40° full scale range so that deviations from the desired process temperatures become much more visible. At the same time, a signal light will indicate the range on which the instrument is operating. The range change is accomplished in a very simple manner by switching various resistors in one bridge arm.

We now have an instrument, the indication of which is visible at a substantial distance, with great flexibility, and any desired sensitivity. It shares its remote-indicating characteristics with the off-and-on controller described above. If we now open the case and remove the chart and chart holder, we will find the conventional chart drive. That is, however, where the conventional designs end. Beyond the chart drive, we find no gears or levers in the instrument. The pointer shaft is ¼° diameter. It may be driven by a slow-speed motor or by a pair of solenoids, or a number of other ways available without gears or rods.

The pointer shaft and the pen shaft are provided with pulleys connected by a non-stretchable belt. The belts can be guided around idlers so that the pen shaft can be placed in any desired position. The mechanism is extremely rugged; in fact, every part is comparatively large. No instrument maker is required for its maintenance, as its construction is that of a small machine.

Where the instrument is installed on a panel in the Control Room and panel space is at a premium, we want a strip chart instrument. This can be designed in two forms: a 10" chart recorder for conventional use; and one with a 3" chart where the process temperature is at the center and the instrument only records deviations from the set temperature.

The mechanism of the strip-chart recorder is almost identical with that of the round-chart instrument. The potentiometer shaft is again motor-driven and carries a pulley. The belt which now carries pointer and recording pen

moves both along a straight guide parallel to the scale.

To save panel space, the chart roller might be arranged in a vertical instead of a horizontal fashion, the finished chart being accumulated in a suitable pocket provided in the case.

It would, of course, be possible to arrange an instrument in such a way that it would *print* the temperature reading every so often—for instance every six seconds—together with the time, on adding-machine tape. This arrangement might be popular with some of the oil companies where the bill for charts runs to many thousands of dollars per year.

Recording and Indicating Controller

To add control to the indicator-recorder is easy. It is of course possible to proceed in the conventional way and add controlling members to the electronic circuit. There is, however, a much better way. We have at our disposal a motor-driven shaft with more than sufficient torque to carry out any desired function. Therefore, we arrange another supporting circle concentric with the scale of our round-chart recorder or a metal bar parallel to the scale for our strip chart instrument.

On these supports we arrange one or more specially designed toggle switches which are operated by the passing pointer. Each switch has a high, low and off position, giving three control points. A number of switches might be added either to increase or decrease fuel or heater current or to admit steam or air to the process or to carry out any other desired function.

If proportional control is desired, the pointer will slide over a resistor covering the desired throttling range. A positioning resistor on the valve in combination with an electronic detector will take care of positioning the valve. We are thinking again of an electrohydraulic or an electropneumatic valve operator. It does not take great ingenuity to provide other types of control than proportional.

Conclusion

While the instrument described in this article has never been built in its entirety, all its component parts have been used in one way or another and found to be practical and reliable.

It appears that this instrument of the future will have some material advantages over the conventional ones of today.

In the first place, it is inherently suitable for remote operation. Distance of a few hundred feet between the primary element and the indicator or control assembly would not effect it at all. Distances of a mile or more can probably be covered without too much trouble if such a requirement should arise.

A sensitivity can be made anything that might be required from ±1° to 0.001°, if it be so desired. An insistent demand is beginning to appear for instruments of more than ordinary sensitivity, though I have never heard anyone ask for an indicator or controller to measure differences of 0.001°. I can, however, see some uses even for this degree of sensitivity.

It would, for instance, be quite feasible to use two primary elements immersed in the stream or the batch at different points. They are part of two bridges, one element being common to both. The signal would then be the sum or difference of the unbalance of the two bridges. The one would control temperature, the other one would increase the speed of correction or start the corrective action earlier in case the heat input (and with it, the heat gradient between the two positions) is increasing. This would be a genuinely anticipatory control. The great sensitivity of the instrument would cause it to start the corrective action long before a significant temperature difference appears in the batch. This higher degree of sensitivity can be obtained with almost no sacrifice of ruggedness or reliability. Remember that the instrument contains no low-torque galvanometer, the measuring system being either a rugged relay or, in the worst case, a 0-to-1 milliammeter of the high-torque variety. The reliability of the instrument, if properly installed, should exceed that of almost anything now in use.

The instrument described has never been built in its entirety but all its components have been used and found practical. All basic engineering materials are available. The incentive to build and market better instruments exists. Let's go!

Accuracy of indication and stability are hard to define. In our case, it will depend principally on the stability of the sensing units. Changes in other parts of the instrument would hardly affect its indication.

While the final evaluation of the stability of the sensing unit can be made only after a large number of them have been used for some time, the stability of these units has so far been very satisfactory. Simplicity and ruggedness of the instrument movement would permit any good mechanic to take care of it. There are no complicated electrical devices which are difficult to understand and no delicate mechanism requires the ministrations of an instrument maker.

Another advantage is offered by the great flexibility of design. The instrument can easily be varied to perform almost any function desired. It would be not too difficult to make the temperature sensitive element interchangeable with sensing elements for pressure.

There will be no difficulty whatever in applying the same system to the measurement of flow.

There are probably as many solutions to the problem of advanced instrumentation as there are men who undertake the task of designing instruments.

In this article we have sketched out one particular method which seems to the writer to be obvious, practical and comparatively easy of execution. In it, a number of comparatively novel design elements have been combined into a practical device.

There are obviously other ways to do the same thing.

Let me submit one more thought before concluding. The old-line instruments have grown up like Topsy, sometimes without rhyme or reason. This did not happen because of any ignorance on the part of the designers. It happened because when industrial instrumentation began its career, there were only a few ways of accomplishing the desired results. The characteristics of these instruments were just what the state of the art in the early days permitted them to be.

As they were competing against "nothing flat," they were better than no instruments at all.

In the later developments, however, a great deal of inertia developed because of the understandable tendency to use some of the old dies, and well-tried methods in designing. New and untested design elements were frowned upon because it was difficult and costly to test them so thoroughly as to obtain a sound comparison with those which had been in use for many years.

Now, however, conditions have thoroughly changed. There are design elements available, which offer such points of superiority that the effort and cost of testing them are well worth while. At the same time, demands for instruments which will do what cannot be done now, are becoming ever more frequent and insistent.

The basic engineering material for the instruments of the future is available now. So is the incentive to build them and market them. Therefore, let us go ahead and "the Devil take the hindmost."

Manometers for Low Pressures*

By SAUL DUSHMAN, Assistant Director, Research Laboratory, General Electric Co., Schenectady, N. Y.

Introduction

THE extensive developments in the application of high-vacuum technique which have taken place during the past twenty-five years have necessitated, as a natural consequence, simultaneous developments in devices for the measurement of low pressures. The following discussion is intended to present a brief review of these different types of manometers, and the fundamental physical principles on which they are based. The author has made use of two previous publications on the same topic.[1, 2] A much more comprehensive discussion of the same subject will appear as a chapter in *The Scientific Foundations of High Vacuum Technique*, a book which is being completed at the present time.

The range of pressures of interest in vacuum technique may be designated at that below 1 mm. of mercury, and for very low pressure work, that below 10^{-3} mm. (=1 micron or 1μ).**

For pressures ranging above 1 mm., a U-tube manometer or Bourdon spiral type of gage is customarily used. A number of suggestions have been made for increasing the sensitivity of these gages to read lower pressures. The *Rayleigh gage*[3] represents one of the earliest suggestions. In the *optical lever manometer*, described by J. E. Shrader and H. M. Ryder,[4] the same objective is attained by a very simple construction, for which a sensitivity of 10^{-3} mm. is claimed. Modifications of this construction have been devised by E. K. Carver,[5] M. L. Hamlin,[6] and K. Newbury and C. L. Utterback[7] by which pressures as low as 5×10^{-3} mm. may be measured.

However, the most generally used type of mercury manometer in vacuum technique is that first described by *McLeod* in 1874, and which depends for its operation on the application of Boyle's law. If P denotes the pressure to be measured, a volume V of the gas is compressed into a much smaller volume v at a pressure p, which can be measured directly. Since

$$P = (v/V)p \quad . \quad . \quad . \quad (1)$$

it is possible, by suitable choice of values of v and V, to measure pressures as low as $10^{-3}\mu$, with values of p in the range 1 to 10 mm. or more.

Inasmuch as descriptions of this gage are readily available in the literature and a number of designs are listed in manufacturers' catalogs, further discussion may be omitted.

Since the McLeod gage does not measure "condensable" gases such as water vapor and the pressure of mercury at room temperature is about 2μ, it is not satisfactory for a number of applications. Furthermore, since the ratio V/v cannot be made too large for a practical gage, the lower limit of pressure of non-condensable gases that can be measured is ordinarily about 0.1μ. However, it is possible, by suitable choice of values of v and V, to design a McLeod gage which has a sensitivity of $10^{-3}\mu$. Such a gage must then be operated by means of stopcocks connecting the mercury reservoir to atmospheric pressure and vacuum, in order to raise and lower the mass of mercury which has to be used to fill the large volume V.

For the quantitative measurement of pressures so low (usually around 1 micron and lower) that the mean-free paths of gas molecules are of the same order or greater than the linear dimensions of the different parts of an exhaust system, the relations for a number of the properties of gases become quite simple. It is therefore possible from quantitative measurements of these properties to determine the magnitude of the pressure.

The different types of low-pressure gages may be classified as follows, by the principles involved in their operation:

1. Viscosity
   a. Decrement (quartz fibre, etc.)
   b. "Molecular" (rotating disk)
2. Radiometer (Knudsen)
3. Heat Conducting
   a. Thermocouple
   b. Wire resistance (Pirani-Hale)
   c. "Thermistor"
   d. Linear expansion of wire
4. Ionization
   a. Hot cathode
   b. Cold cathode (Philips)
   c. Alpha particle source ("Alphatron")

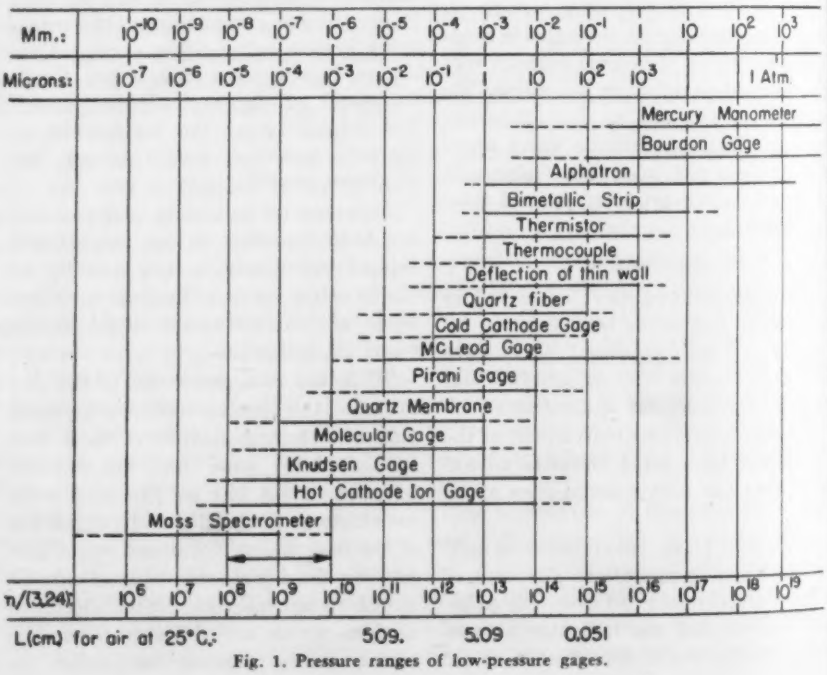


Fig. 1. Pressure ranges of low-pressure gages.

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept. 16-20, 1946.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

**The unit of pressure in the c.g.s. system is 1 dyne/cm.^{2}, which is designated 1 microbar (formerly designated as 1 barye).

1 microbar = 0.75μ
1 atmosphere = 760 mm. Hg.
= 1.01325×10^6 microbars
= 1.01325 bars
750 mm. Hg. = 1. bar

(1) M. F. Behar, "Pressure Measuring Instruments" (Sec. 18, "High-vacuum Instruments") *Instruments*, Vol. 4, 1931, pages 231-242.

(2) M. Pirani and R. Neumann, "High Vacuum Gauges," *Electronic Engineering*, Vol. 17, 1944, pages 277-280, Vol. 17, 1935, pages 322-326, 367-371, 422-426.

(3) Lord Rayleigh, "On a New Manometer and on the Law of the Pressure of Gases Between 1.5 and 0.01 mm Mercury," *Philosophical Transactions, A*, Vol. 196, 1901, pages 205-223; "Über ein neues Manometer und über das Gasdruckgesetz zwischen 1.5 und 0.01 mm Quecksilber," *Zeitschrift für physikalische Chemie*, Vol. 37, 1901, pages 713-734.

(4) J. E. Shrader and H. M. Ryder, "An Optical Lever Manometer," *Physical Review*, Vol. 13, 1919, pages 321-325.

(5) E. K. Carver, "An Improved Optical Lever Manometer," *Journal of the American Chemical Society*, Vol. 45, 1923, pages 59-63.

(6) M. L. Hamlin, "A Laboratory Vacuum Gage," *Journal of the American Chemical Society*, Vol. 47, 1925, pages 709-712.

(7) K. Newbury and C. L. Utterback, "A Low Vapor Pressure Gauge," *Review of Scientific Instruments*, Vol. 3, 1932, pages 593-595.

Fig. 1* shows the approximate ranges of these gages. The full line indicates the usual range, and the dashed portions to the left indicate sensitivities which have been realized by specially designed constructions.

The two bottom rows give values of $n/(3.24)$, where n denotes the number of molecules per cm.^{3} at 25°C., and of L, the mean free path in cm. for *air* at 25°C. Thus, at a pressure of 1μ, $n = 3.24 \times 10^{13}$, and $L = 5.09$ cm.

Values of L (in cm.) at 25°C. and 1μ for a number of other gases are as follows:

Gas	L
H_2	9.31
He	14.72
Ne	10.45
N_2	4.99
O_2	5.40
A	5.31
CO_2	3.34

Viscosity Type Gages

If a surface is set in motion with velocity u in a direction lying in the plane of the surface, then, at low pressures, the rate of transfer of momentum to the molecules incident on the surface is given by a relation of the form

$$B = K u p (M/T)^{\frac{1}{2}} \quad . \quad . \quad (2)$$

where K = constant, M = molecular weight of gas and T = absolute temperature in degrees Kelvin.

In applying this equation two different methods have been used. In the first of these, which is applied in what we may designate as the *decrement* type of gage, a disk is set in oscillation in its plane and the rate of decrease of the amplitude of oscillation is taken as a measure of the pressure. Physically, the damping may be explained as due to the gradual equalization of energy between the oscillating disk and the incident molecules.

In the second method, a disk is set in rotation and the amount of torque imparted to an adjacent surface is used to measure the pressure. A "molecular" type of gage based on this principle was suggested by I. Langmuir[8] and subsequently constructed by the writer.[9] As a device for the measurement of low pressures, it is not very practical and, as far as the writer is aware, this particular type of gage has not been used by other investigators.

A decrement type of gage was first suggested by W. Sutherland,[10] and a careful investigation on its operation was carried out by J. L. Hogg.[11] As in the case of the molecular gage, this device is not nearly as convenient as other designs, especially those using quartz fibres or quartz membranes.

The use of a vibrating quartz fibre was first suggested by I. Langmuir[12] and applied by F. Haber and F. Kirschbaum[13] to measure the vapor pressures

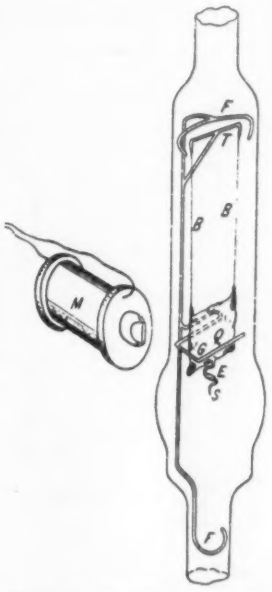


Fig. 2. Quartz membrane gage.

of water, iodine and mercury. The gage consists of a fine quartz fibre sealed into the top of a glass tube. The fibre is set in oscillation by gently tapping the glass bulb and the rate of decrease of the amplitude of vibration is then observed by means of a telescope and lamp. Theoretical considerations lead to the following relation for the determination of the pressure. Let $t_{0.5}$ denote the interval of time required for the amplitude to decrease to half value. Then,

$$p\sqrt{M} = (B/t_{0.5}) - C \quad . \quad (3)$$

where B and C are constants characteristic of the fibre. With a very fine fibre (3.8 cm. long and 0.0045 cm. diameter) it is possible to measure pressures as low as 0.1 micron.

The difficulty encountered in getting the fibre to vibrate in a definite plane has led several investigators to devise a bifilar form of gage in which two fibres are fused together at the free end to form a V or the two fibres are fastened at the lower ends to a strip of metal.

A considerable increase in the sensitivity of this type of gage was obtained by E. Brüche[14] by the use of a quartz surface supported by two quartz fibres. The details of construction are shown in Fig. 2. To the supporting rod, T, are fastened two flat quartz fibres 75 mm. long and 0.8×0.1 mm. cross-section. These are attached to a quartz membrane 25×25 mm. in area and 0.4 mm. thick. This membrane has fastened to it, at the bottom, a very thin-walled small quartz tube in which is sealed a piece of iron wire, E, 7 mm. long and 0.5 mm. diameter. Below this is a pointer, S, which is used to indicate the amplitude of vibration. A fork, G, limits the extent of the vibration. A 4-cm. diameter tube encloses the vibrating system.

Brüche confirmed, by observations with a number of gases, the validity of equation (3) over the range 0.5μ to 20μ. More recently the theory and applicability of this type of gage has been discussed very comprehensively by G. Wetterer,[15] and he has shown that the above equation is a special case of a more general relation between p, M, and the dimensions of the membrane and fibres. From the plots which he has made of these relations it follows that it should be possible to design a quartz membrane manometer to measure pressures as low as $10^{-6}\mu$.

Radiometer Gage

From his investigations on the properties of gases at low pressures, M. Knudsen concluded that there is a mechanical force exerted between two surfaces maintained at different temperatures in a gas at low pressure. This is due to the fact that the molecules striking the hotter surface rebound with a higher average kinetic energy than those that strike the cold surface. On the basis of this phenomenon Knudsen constructed a gage, the operation of which may be explained by referring to the lower part of Fig. 3. Let us consider two parallel strips A and B placed at a distance apart which is less than the mean free path of the molecules. Let A be at the same temperature, T_0, as the residual gas, while B is maintained at a higher temperature, T_1. On the side away from B, A will be bombarded by molecules having an average energy corresponding to the temperature T_0. These molecules will, of course, rebound with the same velocity. However, on the

*Suggested by the chart "Pressure Measuring Instruments — Classes & Types and Ranges of Applicability" in "Pressure Measurement" by M. F. Behar, *Instruments*, Vol. 3, Dec. 1930, pages 729-774. This chart (on page 741) was the first of its kind. This same type of presentation was used more recently in Fig. 1 of "Radium Type Vacuum Gauge" by G. L. Mellen, *Electronics*, Vol. 19, April 1946, page 143.

(8) I. Langmuir, "A New Vacuum Gage of Extreme Sensitiveness," *Physical Review*, Vol. 1, 1913, pages 329-342.

(9) S. Dushman, "Theory and Use of the Molecular Gauge," *Physical Review*, Vol. 5, 1915, pages 212-229. Also see Dushman, "High Vacuum," 1922, page 100; Pirani and Neuman, loc. cit.

(10) W. Sutherland, "Two New Pressure Gauges for the Highest Vacua," *Philosophical Magazine*, Vol. 43, 1897, pages 83-99.

(11) J. L. Hogg, "Friction and Force Due to Transpiration," *Proceedings American Academy*, Vol. 42, 1906, pages 115-146.

(12) I. Langmuir, "Chemical Reactions at Very Low Pressures," *Journal of the American Chemical Society*, Vol. 35, 1913, pages 105-127.

(13) F. Haber and F. Kirschbaum, "Messung kleiner Drucke mit einen schwingenden Quarzfaden," *Zeitschrift für Elektrochemie*, Vol. 20, 1914, pages 296-305. Also see Dushman, "High Vacuum," page 97.

(14) E. Brüche, "Über das Flächen — und Fadenmanometer," *Annalen der Physik*, Vol. 79, 1926, pages 695-733.

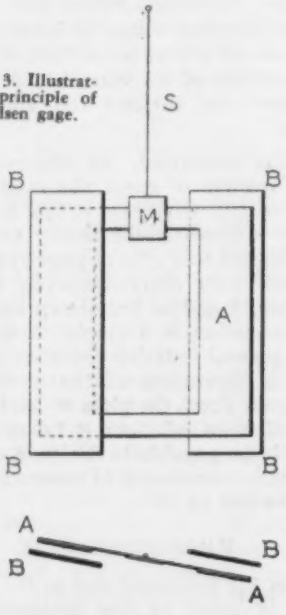
(15) G. Wetterer, "Ein neues Quarzfadenmanometer hoher Genauigkeit und Einfachheit," *Zeitschrift für technische Physik*, Vol. 20, 1939, pages 281-283, and "Ein neues Quarzfadenmanometer hoher Empfindlichkeit und Einfachheit, I," *Wissenschaft. Veroeffentlichungen der Siemens-Werken*, Vol. 19, 1940, pages 68-88.

side towards B, A will be bombarded by molecules coming from B, and having a higher kinetic energy corresponding to T_1. Consequently, A will receive momentum at a greater rate on the side towards B than on the opposite side and will, therefore, be repelled from B. For small differences of temperature, the relation between the pressure and the repelling force, F, assumes the form

$$P = 4F[T_0/(T_1 - T_0)] \quad . \quad (4)$$

That is, F is proportional to P and independent of the molecular weight of the gas. In order to measure F, Knudsen used the arrangement shown diagrammatically in the upper part of Fig. 3. The strip A is replaced by a rectangular vane, cut out in the center and suspended by means of a fibre S. Two strips, BB, which can be heated, are placed symmetrically on opposite sides of this vane, and the force of repulsion is then balanced by the torsion of the fibre. By means of the mirror, M, the deflection can be measured in the same manner as in the case of a galvanometer. The magnitude of F may be calculated from the values of the moment of inertia of the vane, its mean radius, the area opposite each strip B, and the period of vibration of the vane. Hence the device can be used as an *absolute manometer*, without the necessity of calibrating against any other gage.

Fig. 3. Illustrating principle of Knudsen gage.

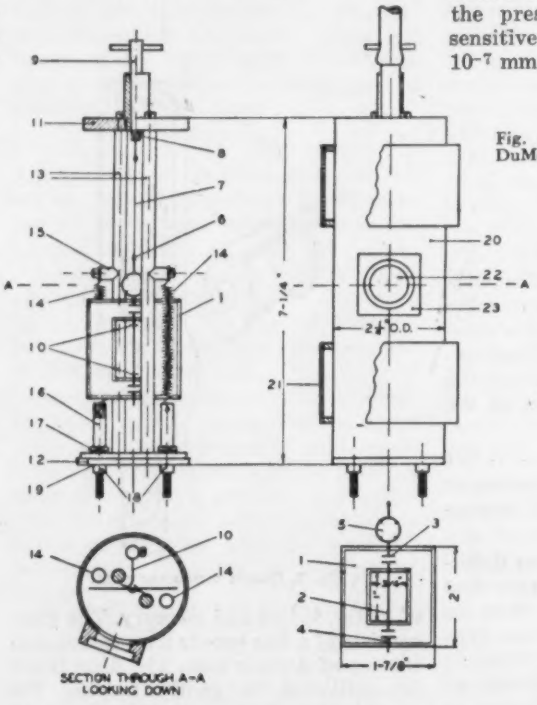


Knudsen, as well as a number of subsequent investigators, described different forms of the radiometer gage which vary in sensitivity and ease of construction. The designs used by J. W. Woodrow[16] and J. E. Shrader and R. G. Sherwood[17] are of special interest since they were in glass envelopes and could be baked out at high temperatures.* With a temperature difference of 100°C., pressures as low as $10^{-5}\mu$ could be measured.

The most recent construction of Knudsen gage is that devised by Jesse W. M. DuMond and W. M. Pickels, Jr.[18] Fig. 4 is a line drawing of this gage.

The movable vane 1 consists of a rectangular frame of 2.5-mil aluminum to which is fastened an axle 2 of 32-mil aluminum. This axle carries an ordinary galvanometer mirror 5, which is attached to a 0.5-mil tungsten wire. The latter is fastened to an aluminum wire which is held by means of a set screw 8 in the hole in the bottom of the steel taper plug 9. A vacuum-tight seal is obtained by means of laboratory wax or stopcock grease. The heaters 14 are helices of chromel resistance wire and the current leads are provided by means of the insulated vacuum-tight plugs which are fastened by the nuts 18. The cylindrical brass envelope 20 of the gage with its window and water jackets 21 is slipped over the brass disks 11 and 12 and sealed at 12 by means of solder or apiezon wax. Two Helmholtz coils outside the case are used to obtain magnetic damping.

Fig. 4. Gage designed by DuMond and Pickels.



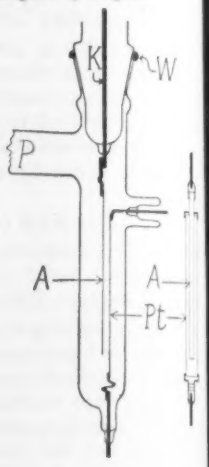
"Instead of maintaining," the investigators state, "the gage heater at constant temperature for all gas pressures in the gage, we let the heater assume whatever temperature the combined effect of radiation loss and gas conduction loss impose with a constant wattage input to the heater." Under these conditions, the relation between deflection of the mirror D and pressure is not linear but has the form,

$$D = CP/(1 + BP) \quad . \quad (5)$$

where C and B are two constants which are derived from a calibration of the gage against a McLeod gage (with liquid air trap inserted between the latter and the Knudsen gage).

The deflection is observed by means of a small lamp and galvanometer screen. By varying the wattage in the heater coils two scales are obtained for the pressure readings. On the more sensitive of these, pressures as low as 10^{-7} mm. can be detected.

Fig. 5. Simple Knudsen gage designed by Hughes.



A more rugged form of Knudsen gage, which is not quite as sensitive as that devised by DuMond and Pickels, has been described by A. E. Lockenvitz.[19]

In contrast to the last two gages is the simple design described by A. Ll. Hughes,[20] which is shown in Fig. 5. It consists of a Pyrex tube, 2.5 cm. in diameter and 15 cm. long. The heater, Pt, is made of a platinum strip 10 cm. long, 1.3 cm. wide and 0.0001 cm. (0.4 mil) thick, and is connected to two 50-mil tungsten leads. The movable strip, A, is made of aluminum leaf, 12 cm. long, 0.4 cm. wide, and 5×10^{-5} cm. (0.2 mil) thick. The strip is fastened to a 50-mil tungsten lead which is sealed in the ground glass joint. The latter is sealed on the *outside*, as shown, by a suitable wax which has very low vapor pressure. The author states that "the aluminum leaf is connected electrically to the heater to ensure that no electrostatic effects causing undesirable deflections of the leaf can occur. The motion of the tip of the free end of the

(16) J. W. Woodrow, "Experiments on the Production and Measurement of High Vacua," *Physical Review*, Vol. 4, 1914, pages 491-497.

(17) J. E. Shrader and R. G. Sherwood, "Production and Measurement of High Vacua," *Physical Review*, Vol. 12, 1918, pages 70-80.

*See detailed description in Dushman, *High Vacuum*, pages 107-112.

(18) J. W. M. DuMond and W. M. Pickels, Jr., "Superiority of a Knudsen Type Vacuum Gauge for Large Metal Systems with Organic Vapor Pumps; Its Design and Operation," *Review of Scientific Instruments*, Vol. 6, (1935), pages 362-370. The gage is available from manufacturers.

(19) A. E. Lockenvitz, "A Radiometer-Type Vacuum Gauge," *Review of Scientific Instruments*, Vol. 9, 1938, pages 417-420.

(20) A. Ll. Hughes, "Simple Knudsen Gauge," *Review of Scientific Instruments*, Vol. 8, 1937, pages 409-412.

leaf is measured by means of a reading microscope with 100 divisions in its scale. Seventeen divisions correspond to 1 mm. Current to raise the temperature of this heater is provided by a storage battery and measured by an ammeter."

The sensitivity of this gage increases with increase in heating current and at the highest current used, one scale division is equal to about 0.3μ.

Radically different constructions have been described by H. Klumb and H. Schwarz[21] and also by W. Gaede.[22] The "Molvakumeter" devised by the latter combines features of both the decrement type of gage and the Knudsen type. However, both these designs are in the nature of highly specialized laboratory devices not suitable for more general application.

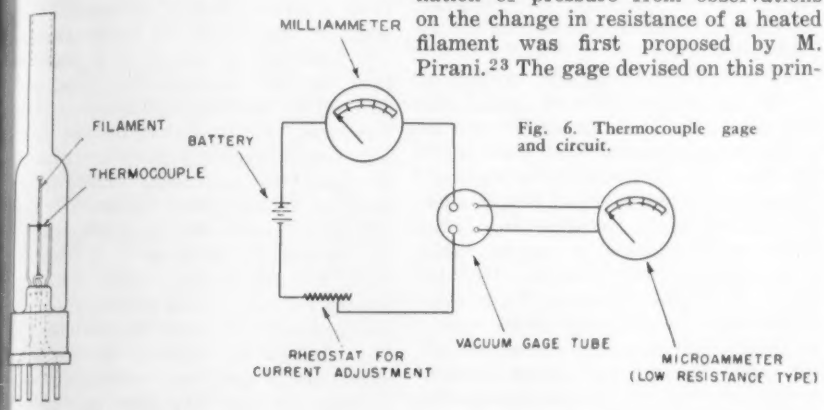


Fig. 6. Thermocouple gage and circuit.

Heat-Conductivity Manometers

At low pressures the thermal conductivity of a gas varies linearly with the pressure. If the energy supplied to a given surface is maintained constant, as is usually the case in gages of this type, the temperature of the hot surface decreases with increase in pressure and the different types of conductivity gages involve different methods for determining the change in temperature of the hot surface due to the gas. In the thermocouple type, the temperature is observed by means of a thermocouple spot-welded at the center of a heated wire; in the resistance gage, the change in resistance of a heated filament is measured; in the "thermistor," the change in resistance is determined of a bead made of semi-conducting material, and finally, since the length of a wire varies with temperature, this leads to a third method for measuring the effect of gas pressure.

(A) *Thermocouple Gages.* Many designs of this type of gage have been described. The construction and appropriate circuits of such a gage developed in this laboratory (by N. T. Gordon) are shown in Fig. 6. It consists of a platinum-iridium ribbon (3.66 × 0.0234 × 0.0078 cm.), to the center of which is welded a thermocouple of nichrome-advance ribbon (0.01 × 0.00125 cm.), all mounted on a four-lead stem in a tubular bulb. A constant current of approximately 0.030 to 0.050 amp., depending on the range of pressures to be measured, is passed through the filament and a sensitive millivoltmeter is used to read the thermocouple e.m.f. The heater filament operates at a temperature varying from 100 to 200°C. Fig. 7 shows semi-log plots of pressure versus millivoltmeter readings obtained by means of this gage for H_2, N_2 and Xe. In these observations the walls of the gage were at room temperature. As will be observed the most sensitive range is 0.01 mm. to 0.1 mm.

(B) *Pirani-Hale Gages.* The determination of pressure from observations on the change in resistance of a heated filament was first proposed by M. Pirani.[23] The gage devised on this principle was subsequently improved by C. F. Hale,[24] and its use in vacuum technique has become widespread.

The construction of the gage and the accompanying electric circuit are quite simple. A length of platinum (or tungsten) wire is mounted on a glass stem carrying radial supports and sealed into a tubular bulb. Two duplicate bulbs are used, one of them being attached to the system in which the pressure is to be measured, and the other (the "compensator") is exhausted carefully to as good a vacuum as possible. These two tubes are inserted in the arms of a Wheatstone bridge arrangement and a constant current passed through the two filaments in series. The resistance of the filament connected to the system changes with gas pressure and the magnitude of this change is then determined in the usual manner.

The commercially-available forms of the gage are, in general, calibrated for the range 0 to 250 microns, but in laboratory investigations, it has been found possible to use designs by means of which pressures as low as $10^{-4}\mu$ can be measured.

Since the thermal conductivity of a gas varies with the composition, the gage must necessarily be calibrated for each gas. Thus hydrogen and helium have considerably higher conductivities than air and carbon dioxide.

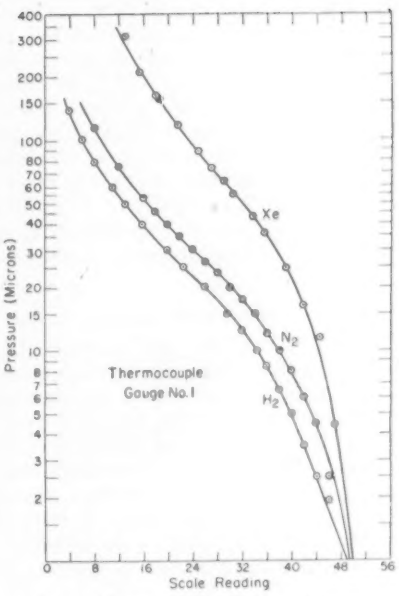


Fig. 7. Calibration of thermocouple gage.

(C) *"Thermistor" Gage.* J. A. Becker, C. B. Green and G. L. Pearson[25] have designed a gage in which the resistance consists of a small bead of semi-conducting material (designated thermistor) which is fastened to two leads and sealed into a small bulb. This material has a high negative temperature coefficient of resistance. As in the Pirani-Hale gage, two elements are used, with matched characteristics, so that they can be operated in adjacent arms of a Wheatstone bridge. The bridge is balanced under conditions of good vacuum in the manometer and the off-balance current then becomes a measure of the pressure.

The fact that the indications vary practically linearly with pressure over the range from 1 to about 1000 microns gives this type of gage an advantage over the thermocouple type which makes it extremely useful in vacuum technique.

(D) *Linear Expansion Type.* Manometers based on this principle have been devised by a number of investigators. The most practical forms are those which involve the use of a bimetallic strip. H. Klumb and Th. Haase[26] have described three forms of such a gage. In one form the bimetallic strip, which is heated by passing current through it, has fastened to it a large glass fibre with a weight of about 100 mg., and the deflection is observed by means of a

(21) H. Klumb and H. Schwarz, "Uber ein absolutes Manometer zur Messung niedrigster Gasdrucke, *"Zeitscrift für Physik,* Vol. 122, 1944, pages 418-436.

(22) W. Gaede, "Tiefdruckmessungen," *Zeitschrift für technische Physik,* Vol. 15, 1934, pages 664-668.

(23) M. Pirani, "Vacuum Measurement," *Verhandlungen der deutschen physikalischen Gesellschraft,* Vol. 4, 1906, pages 686-694.

(24) C. F. Hale, "On the Measurement of Very Small Gas Pressures," *Transactions American Electrochemical Society,* Vol. 20, 1911, pages 243-258.

(25) J. A. Becker, C. B. Green and G. L. Pearson, "Properties and Uses of Thermistors—Thermally Sensitive Resistors," *Transactions A.I.E.E.,* Vol. 65, 1946, pages 711-725.

(26) H. Klumb and Th. Haase, "Ein Beitrag zur Messung niedriger Gasdrucke," *Physikalische Zeitschrift,* Vol. 37, 1936, pages 27-32.

microscope. In the second form the band is on the form of a spiral having 14 turns and 6 mm. outside diameter. To the lower end of this spiral is attached a galvanometer mirror and the deflections are observed optically. In the third form compensation is provided for variations in external temperature by means of a second spiral made of a similar bimetallic strip. With this type of gage it is possible to measure pressures as low as $10^{-2}\mu$.

Ionization Gages

When electrons are accelerated through a potential ranging from about 50 volts to 250 volts, ions are formed by collision of electrons with gas molecules, and for not too large electron currents the number of positive ions, at constant accelerating voltage, varies linearly with the pressure. Any form of triode may be used as an ionization gage and Fig. 8 shows a typical arrangement of the circuits for carrying out such pressure measurements. Electrons emitted from the hot tungsten filament F are accelerated by +150 volts applied to the grid G and cause the formation of positive ions. The latter are collected on the plate C which is at a negative potential (−20 to −25 volts) with respect to the cathode. For pressures in the range below about 1μ and for electron currents of about 5 ma. or less, the positive ion current (i_P) varies linearly with the pressure (p) and with the electron current (i_E). The sensitivity (S) of such a gage is defined by the relation,

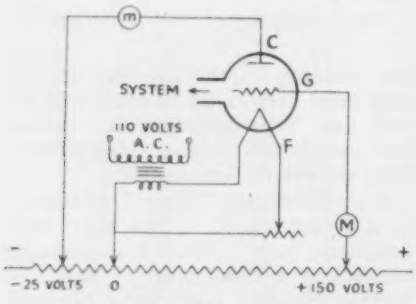


Fig. 8. Circuit for an ion gage.

$$S = i_P/(p \cdot i_E) \quad . \quad . \quad . \quad (6)$$

For any given arrangement of the three electrodes, and at constant voltage on the grid, S varies with the nature of the gas, and for any given gas, the value of S increases with the grid voltage, although this increase is not, in general, linear with that in voltage.

A large number of constructions have been suggested which differ in geometrical shape, size and spacing of the electrodes. In order to avoid electrical leakage between cathode and collector, which is likely to be troublesome if the three electrodes are mounted on the same stem (as is customary in receiving or transmitting triodes), the collector is connected, in more sensitive gages, to a separate stem or lead. In the gage designed by R. S. Morse and R. M. Bowie,[27] which is available commercially and widely used, the positive ion collector consists of a platinum film deposited on a portion of the inner wall of the cylindrical tube.

TABLE I. (i_E=1.0 ma.)

Gas	FP-62(1) $S \times 10^3$	FP-62(1) r	FP-62(2) $S \times 10^3$	FP-62(2) r	VG-1 $S \times 10^3$	VG-1 r	Average Value r
He	0.77	0.140	0.70	0.133	2.88	0.127	0.133
Ne	1.08	0.196	1.08	0.205	4.65	0.206	0.202
A	5.50	1.0	5.27	1.0	22.6	1.0	1.0
Kr	8.9	1.62	8.4	1.59	32.9	1.46	1.56
Xe	12.0	2.16	13.0	2.46	50.9	2.25	2.29
Hg	15.0	2.73	14.5	2.75	72.0	3.18	2.89
H_2	2.14	0.39	2.10	0.40	8.65	0.38	0.39
N_2	4.90	0.89	4.40	0.83	18.2	0.81	0.84

In some designs a thoriated tungsten cathode is used, and in still others, oxide coated cathodes. Many users of ionization gages prefer the latter because of the fact that a sudden rush of air, due to occurrence of a leak, is not as likely to burn out this type of cathode as one of tungsten. For instance, an oxide-coated cathode is used in the gage described by C. M. Fogel.[28]

An investigation on the calibration of the gage for different gases was carried out by N. B. Reynold[29] and recently more extensive work was carried out by A. H. Young and the writer.[30] While the actual value of the sensitivity as defined in equation (6) for a given gas, for instance argon, varies from about 5×10^{-3} to 25×10^{-3} for different designs of gages, the relative sensitivities for different gases with a given type of gage, are approximately the same. Table I gives data obtained by the last-mentioned investigators with three different constructions of gages.

The table shows that in the case of argon, the VG-1 type has a sensitivity of about 22.6×10^{-3} microamps per micron per milliampere electron current, while the FP-62(2) has a value of $S = 5.27 \times 10^{-3}$ microamps per micron per milliampere.

The data in the columns headed "r" give the values of the sensitivities for different gases relative to that for argon as standard. As will be observed, the values of r for all three gages are about the same. In the case of the rare gases and mercury, the values of S decrease approximately exponentially with increase in ionizing potential of the gas.

One of the greatest disadvantages of the hot-cathode type of ion gage is the fact that chemically-active gases such as oxygen and hydrocarbon vapors tend to poison or even destroy the cathode. In many vacuum-technique operations it is necessary to introduce air from time to time in order to seal on a fresh tube. Then the ion gage has to be re-exhausted and the gases adsorbed by the electrodes in presence of air have to be eliminated. It is frequently necessary under these conditions to re-activate the cathode.

In order to overcome these difficulties the *Philips Ionization Manometer* was developed by F. M. Penning[31] and has received considerable acceptance.

In this gage, the electrons emitted from a *cold cathode* of zirconium, thorium, or other type of active surface, are deflected by means of a magnetic field, so that the total length of path covered in reaching the anode is many hundreds of times that of the direct distance between the two electrodes. As a result the ionization produced per electron at any given pressure is considerably greater than that which would be obtained in absence of a magnetic field. The magnitude of the total discharge current, which is the sum of the electron current from the cathode and the positive ion current to the same electrode, is used as a measure of the pressure of gas. The gage is sensitive to pressures as low as $10^{-2}\mu$. The microammeter used to measure the current may be replaced by a glow tube having a cathode in the form of a metal rod. The length of the glow along this rod is proportional to the current.

A very ingenious type of cold-cathode gage is that developed by J. R. Downing and G. Mellen,[32] which they have designated the "Alphatron." The ionization of the gas is produced by alpha particles emitted from a radium source. The order of magnitude of the ionization current is 2×10^{-10} ampere per mm. of air. The calibration varies with the nature of the gas. Up to a few mm. of Hg, the ionization varies linearly with the pressure. The lower limit of pressure which can be measured with this gage is between 10 and 1μ.

Control Circuits for Ionization Gages[33]

In the case of the thermocouple and Pirani gages the electric circuits are

(27) R. S. Morse and R. M. Bowie, "A New Style Ionization Gauge," *Review of Scientific Instruments*, Vol. 11, 1940, pages 91-94.

(28) C. M. Fogel, "An Ionization Gauge of Simple Construction," *Proceedings Institute of Radio Engineers*, Vol. 34, 1946, pages 302-305.

(29) N. B. Reynolds, "Studies with an Ionization Gauge," *Physics*, Vol. 1, 1931, pages 182-191.

(30) S. Dushman and A. H. Young, "Calibration of Ionization Gauge for Different Gases," *Physical Review*, Vol. 68, 1945, page 278.

(31) F. M. Penning, "Ein neues Manometer für niedrige Gasdrucke Insbesondere zwischen 10^{-3} und 10^{-5} mm," *Physica*, Vol. 4, 1937, pages 71-75. See also description in "High Vacuum Technique" by J. Yarwood, John Wiley and Sons, Inc., New York, page 48.

(32) J. R. Downing and G. Mellen, "Radium-Type Vacuum Gage," *Electronics*, Vol. 19, 1946, pages 142-146.

(33) See discussion by H. E. VanValkenburg, "Application of the Ionization Gage in High Vacuum Measurement," *General Electric Review*, Vol. 49, 1946, pages 38-42.

relatively simple and different manufacturers have developed convenient portable sets which can be plugged into the ordinary 60-cycle 110-120-volt source.

The requirements for continuous operation of a hot cathode ionization gage are, however, more stringent. As is well known, the electron emission from a tungsten or oxide-coated filament varies exponentially with the temperature and, as mentioned previously, is greatly affected by different gases. Hence it is necessary to arrange maintenance, during operation of the gage, of constant emission. Furthermore, it is essential to have stabilized power supplies for the plate and collector voltages. Finally, since it is desirable to be able to read extremely small ionization currents (of the order of 0.1 microampere and lower) some kind of amplifier system should be provided.

A number of investigators have proposed a variety of electronic control circuits[34] and complete sets for the control of emission and automatic protection of the filament against burnout are available commercially.

Mention should also be made in this connection of a control system for use with a combination of thermocouple and cold-cathode discharge gages which has been described by R. G. Picard, P. C. Smith and S. M. Zollers.[35] Also the authors have proposed a circuit "whereby," according to their publication, "the current from the gages may be used to control equipment so that the pressure in the vacuum system may be used to operate other devices."

General Remarks on Gages

In the different problems that arise in high-vacuum technique, the question usually arises as to what one or two of the assortment of gages described in the previous sections would be most satisfactory. Even if some of the designs described are obviously either impractical or very limited in their application, there still remains a considerable variety from which a choice may be made. One of the most important factors which must be considered is that of range of pressures to be measured. Another factor is the nature of the gas or gases present in the system. Is it necessary to eliminate condensable vapors from the gage? How does the sensitivity of the gage depend upon the nature of the gases or vapors?

The advantages and disadvantages of the principal types of gages for use with organic vapor pumps, have been stated in a paper by J. W. DuMond and W. M. Pickels.[18] Their discussion, which is limited to the McLeod, Pirani, ionization and Knudsen types of gages, is summarized in the following remarks:

The McLeod gage has the following disadvantages: (1) It does not give continuous readings of the pressure. (2) It is insensitive to condensable vapors. (3) In order to eliminate mercury from the rest of the system it is necessary to insert a liquid air trap. "Such traps," it is stated, "are never completely effective over long periods. (4) The readings are never very dependable below 10^{-4} or 10^{-5} mm. Hg pressure."

The ionization gage has a very wide range of pressures, but possesses the following disadvantages: (1) It requires considerable auxiliary electrical equipment. (2) Its sensitivity varies for different gases and vapors. (3) The filament emission may be "poisoned" in presence of certain gases. (4) The filament is susceptible to burn-out if exposed to air while hot. (5) "Ion-bombardment destroys the filament more or less rapidly with continued use." (6) The electrodes must be out-gassed very thoroughly before the gage can be used to give reliable indications, especially at extremely low pressures. (7) The hot filament decomposes certain gases (especially hydrocarbons).

To these disadvantages may be added those due to chemical and electrical "clean-up" effects. The gradual decrease in pressure in an electrical-discharge tube is a well-known phenomenon, which is observed with cold as well as with hot cathodes. Such clean-up occurs with all gases and obviously must be taken into account in the interpretation of observations made by means of an ionization gage. In fact, H. Schwarz[36] has made the following statement: "Everyone who measures pressures under 10^{-4} mm. with the ionization gage must regard his measurements with more or less skepticism."

However, in the experience of the writer, the situation is not quite as bad as this statement would imply. If the plate voltage or current to the filament is applied only during the *very short interval* necessary to observe both the electron and positive ion currents, then the amount of clean-up is reduced to a minimum. That is, the *gage should not be operated continuously* when it is desired to determine the pressure in a sealed-off system. With a circuit such as that devised by Ridenour or Nelson which has been described in the previous section, a pressure determination may be made in a few seconds and it will be found that under these conditions the reduction in pressure is negligible.

As DuMond and Pickels point out, the Pirani or hot wire gage has two main disadvantages: (1) "It is very difficult with it to maintain a stable 'zero' point of pressure and it cannot therefore be used with confidence to measure pressures much below 10^{-4} mm. Hg." (2) As the pressure is decreased below about 10^{-3} mm. Hg, loss of heat by conduction becomes negligibly small as compared with the radiation loss.

"No modification," it is stated, "in the geometrical design of the gage can improve the ratio of energy loss by gas conduction to energy loss by radiation, since at these low pressures the molecules of gas travel in straight lines between the wire and the walls just as the photons of radiation do.

"Now this is the chief reason for the superiority of the Knudsen gage. At these pressures the energy transported by molecules of gas is small compared to the energy transported by photons of radiation, but the *momentum* transported by molecules is huge compared to the momentum transported by photons on account of the comparatively enormous mass of the molecules. The Pirani gage measures the molecular *energy* transport while the Knudsen gage measures the momentum transport, hence its superiority."

The main advantages of the Knudsen type are the following: (1) It requires no auxiliary electrical circuits such as are used with the ionization gage. (2) The deflections of the mirror are proportional to the pressure and correspond to absolute pressures, independently of the nature of the gas.

On the other hand, the use of a suspension involves difficulties similar to those met with in any sensitive galvanometer, especially when dealing with extremely low pressures. Such difficulties will arise whenever the gage is subjected to external causes of vibration. Moreover, in a gage such as that designed by DuMond and Pickels it is very difficult to outgas the parts and any wax or grease joints are apt to be sources of constant gas evolution.

The fact is that each of the different types of gages described in the previous sections possesses both advantages and disadvantages. The experimenter must decide upon the objective of any set of measurements and then choose that gage or those gages which will give him the desired information most conveniently and to the desired degree of accuracy. In many cases information on order of magnitude of the pressure is sufficient, in other cases a continuous record of variation in pressure may be desired, without reference to the nature of gases present.

For instance, in the evacuation of electronic devices the factor of significance is the ratio i_P/i_n, irrespective of the nature of the ions. An ionization gage gives this information directly and while the necessity for using auxiliary electric circuits may appear a disadvantage, the actual fact is that such gages have found extensive application in factory practice as well as in the laboratory.

The same statement applies to the use of a Pirani gage. In both industrial applications of vacuum technique as well as in purely scientific investigations the hot wire gage is widely used, along with the thermocouple and McLeod gage.

(34) R. N. Bowie, "An Ionization Gauge Circuit," *Review of Scientific Instruments*, Vol. 11, 1940, pages 265-267; L. N. Ridenour, "'Magic Eye' Ionization Gauge," *Review of Scientific Instruments*, Vol. 12, 1941, pages 134-136; R. B. Nelson and A. K. Wing, "Emission-Regulating Circuit for an Ionization Gauge," *Review of Scientific Instruments*, Vol. 13, 1942, pages 215-217.

(35) R. G. Picard, P. C. Smith and S. M. Zollers, "A Reliable High Vacuum Gauge and Control System," *Review of Scientific Instruments*, Vol. 17, 1946, pages 125-129.

(36) H. Schwarz "Gasaufzehrung und Gasaustausch bei der Messung niedrigster Drucke im Ionisationsmanometer," *Zeitschrift für Physik*, Vol. 122, 1944, pages 437-450.

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

XI. HIGH-VACUUM TECHNIQUE IN EQUIPMENT PRODUCTION *(Cont'd)*

STATIC VACUUM SYSTEM IN EQUIPMENT PRODUCTION *(Cont'd)*

Strip Silvering.

On occasions it is desirable not to plate a certain portion of the jacket surface. Usually, to gain the maximum reflectivity and yet have some of the surface free of silver plate, it is more convenient to silver both sides and leave a narrow unsilvered section along each side of the flask. Columns and flasks of this nature can be used for high temperatures (200°C.), but are more efficient at low temperatures where the center of the tube is subjected to temperatures of 0 to −40°C.

Strip silvering is carried out in much the same manner as the operation discussed above except that two tubulations

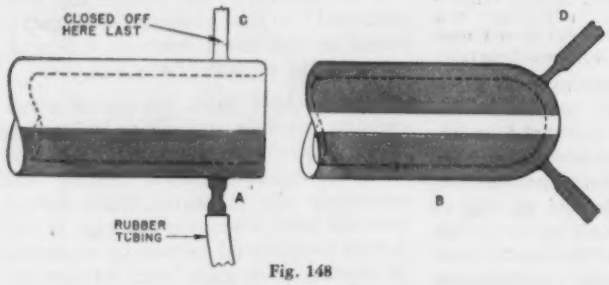


Fig. 148

are required, Fig. 148B, and the silvering solutions 1, 2 and 3 are mixed before the solution is allowed to flow into the flask. The jacket walls must also be completely dry before the solutions are transferred to the jacket. The jacket must have two tubulations and it must be supported rigidly. The solution is then forced to flow slowly with gravity into the jacket through A, until the desired level is reached, Fig. 148. The solution is removed after the silvering is complete and the jacket is dried carefully before inverting. After the silvering is complete on the other side, the jacket is carefully washed and dried by evacuation.

Evacuating Glass-jacketed Equipment

The vacuum that can be obtained and maintained in glass vacuum jackets depends on the method adopted for the evacuation and heating of the equipment. Glass has a tendency to retain various gases and water, which are released at appreciable rates only under heat treatment. If a glass jacket is heated to a temperature near the softening point while it is being pumped and then sealed, a good vacuum will be maintained only for a short time. Gases which have diffused to the surface are retained in part at the surface and are released slowly. The vacuum in the jacket is thus gradually lost and the heat-insulating properties become poor. If the temperature is decreased 100°C. or so from the maximum temperature and pumping is continued, these gases on the glass surface can be pumped out, in part, and better vacuum jackets are obtained. There are, therefore, two phases in the heating and pumping process. The first consists in removing absorbed gases as well as forcing gases to the surface of the glass. The gases at the surface are then pumped from the jacket while the glass is hot.

Irving Langmuir[15] has carried out extensive investigations concerning the heating and evacuation of glass bulbs used for incandescent lamps. Results of this work showed that lamps evacuated at 550°C. and then at 400°C. gave a lamp life of 900 hours as compared to 575 and 300 hours for lamps heated to 450 and 550°C. respectively. The conclusions drawn by Langmuir were that evacuation should be carried out in two or more stages of decreasing temperature.

Investigations of gases evolved from glasses were made by R. G. Sherwood[16] and J. E. Shrader[17]. The results of Sherwood's work with soda, lead and Corning glass G-702-P are graphically shown in Fig. 149. The curves for each glass give the total gas liberated from a glass surface of 350 cm.^{2}. Gas evolution reaches a first maximum at 150, 200 and 310°C. for soda, lead and Corning glass G-702-P respectively. The gas evolution then decreases and again rises at a temperature above the softening point of the glass. Sherwood concludes that the first maximum is obtained by the release of absorbed gases while the actual decomposition of the glass, liberating mainly water vapor, is responsible for the evolution at the higher temperature.

The history of the glass treatment also has some bearing on gas evolution. R. G. Sherwood and I. Langmuir both have found that annealing glass at high temperatures greatly reduces subsequent gas evolution.

The vacuum system shown in Fig. 140 is ideal for evacuating glass-jacketed equipment. The furnace sections can be so arranged that long as well as short equipment can be entirely enclosed by using several or just one hinged heater section.

The glass is baked and evacuated as follows:

1. It is advisable to clean unsilvered jackets with cleaning solution and to rinse several times with distilled water before evacuation. The jacket is then dried at room tempera-

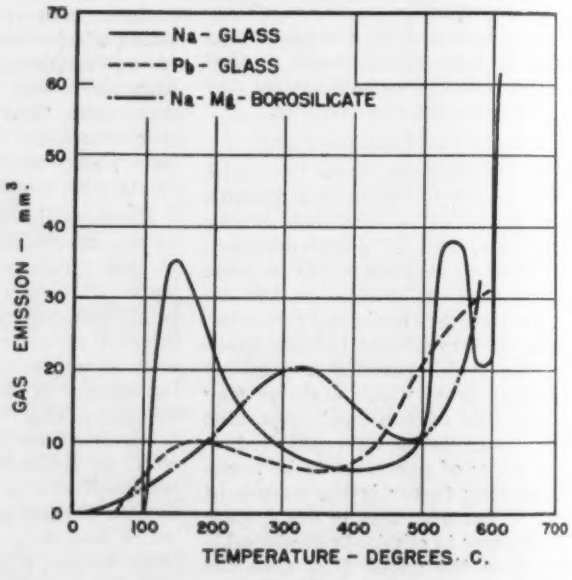
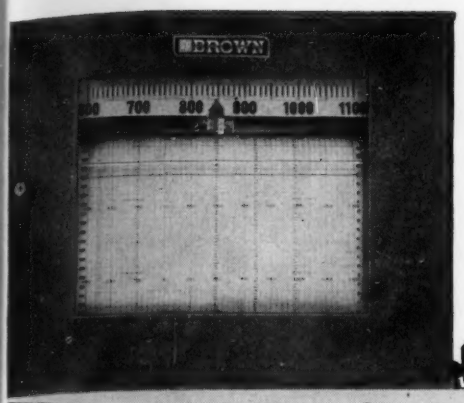


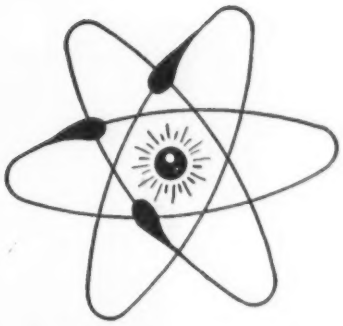
Fig. 149

ture by repeatedly evacuating and filling with dry air. A mechanical pump can be used if a cold trap or drying tube is used between the jacket and pump.

2. The tubulation of the jacket is then sealed to the vacuum system manifold. The jacket is supported in the furnace in such a way that the glass blower can reach the tubulation without removing the entire furnace. If the jacketed equipment is not too heavy it can be suspended in the furnace and held in place by the tubulation. Heavier equipment is supported in such manner that the movement of the equipment is possible when the tubulation is closed by heating and drawing it to a tip. A method of supporting a strip-silvered Dewar is illustrated in Fig. 140.

3. The forepump is started and allowed to pump alone





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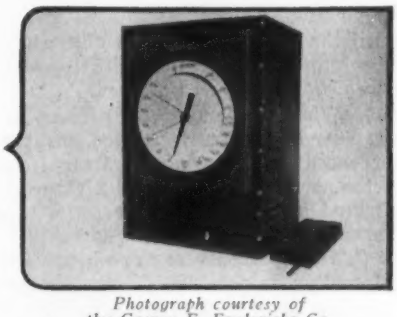

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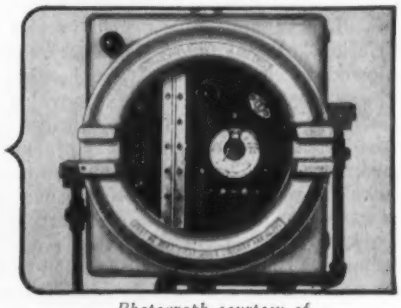

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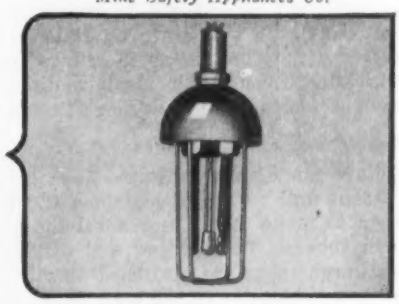

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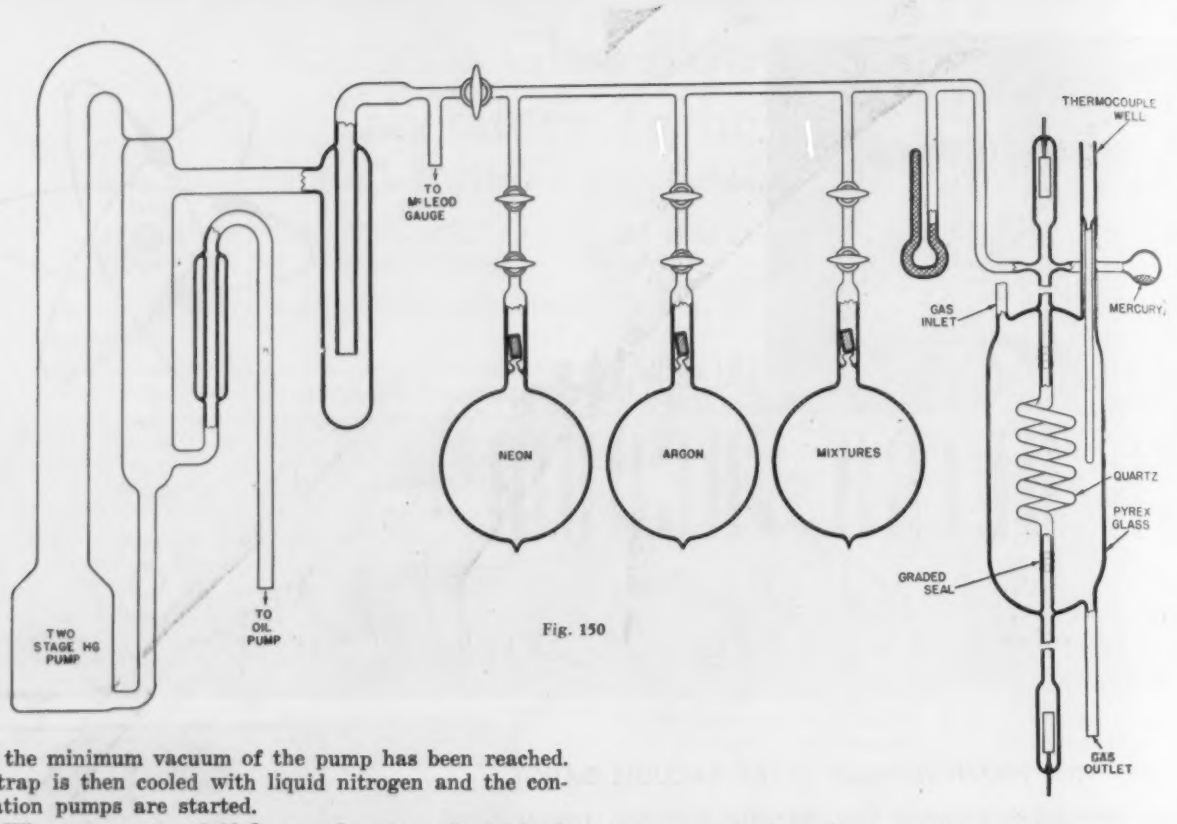

Fig. 150

until the minimum vacuum of the pump has been reached. The trap is then cooled with liquid nitrogen and the condensation pumps are started.

4. When a vacuum of 10^{-7} mm. of mercury is obtained, the furnace heater is turned on. The temperature can be increased rapidly when unsilvered equipment is evacuated. A temperature rise about 1.2°C. per minute is required for silvered jackets. The temperature is raised to 550°C. when Pyrex brand glass No. 774 is being heated and maintained at this temperature for one hour. The temperature is then allowed to drop to 400°C. The equipment is pumped for 30 minutes at this temperature. The McLeod gage reading now should be better than 10^{-5} mm. of mercury.

5. The tubulation is sealed in two operations. The constriction is heated around the entire circumference and it is allowed to close slightly. The heating is stopped and four minutes are allowed for the removal of gases liberated from the hot constricted walls. The glass at the constriction is then heated and collapsed as the jacket is drawn away from the manifold. The tip is then rounded and annealed. The jacket is removed from the furnace and cooled as quickly as possible. Some discretion must be used in cooling hot equipment: if uneven contraction can be set up in critical regions as the condenser illustrated in Fig. 143C, the strains set up between the rapidly-cooling glass and glass that is not cooled are great enough to cause breakage. On the other hand, it has been shown by experiment that gases are liberated at high temperatures. It is important, therefore, to decrease the time so as to reduce the gas evolution to a minimum. Even under ideal conditions, gas evolution can be expected to a minor degree at room temperature.

Rare-gas Discharge Tubes

Rare-gas discharge tubes have become exceedingly important and on many occasions the glass blower is called upon to make them. In general the greatest application of such tubes is for lighting and display purposes. However, discharge tubes are also used as sources of light with definite wave-lengths. It has been found that the mercury ultraviolet lamp is useful for promoting various photochemical reactions. Many different lamps may be designed for such studies. The lamp and reaction chamber combination designed by E. Staecie and N. Phillips[18] is simple and compact and is useful where a source of light is required with a wave-length of 2,537 Angstroms. The construction of this lamp will be given as an example of rare-gas lamp production.

A major requirement for discharge tube production is a good vacuum system. It is necessary to have a suitable source for filling the tubes with rare gas and convenient to combine the vacuum and rare-gas filling system into a single unit such as illustrated in Fig. 150. Special attention is called to the rare-gas storage flask. These flasks filled with rare gases or mixtures are supplied by the Linde Air Products Company. The gas-filled flasks are obtained with a special capsule closure which can be opened by dropping a small pellet on the capsule. Since it is important not to contaminate the gas with any impurities it is necessary to use a pellet which can be thoroughly cleaned. Such a pellet can be made by sealing an iron rod, $\frac{1}{8}$" by $\frac{3}{4}$", into a glass tube. This pellet will be heavy enough to break the capsule when it is dropped from a height of 3" and it can be cleaned quite easily.

Fig. 151

The gas-filled flask can be sealed to the system as illustrated in Fig. 150. The two stopcocks are useful for controlling the flow of gas into the evacuated tube. If large amounts of gases are used it is sometimes convenient to use the arrangement illustrated in Fig. 151. The gas flasks can easily be changed because of the interchangeable ground joint and different glasses can be used, *i.e.*, soda glass on the flask and Pyrex (774) on the system.

In the production of the ultraviolet lamps, it is necessary that the glass of the tube transmits light in the range of the required wave-length. Transmission curves of various glasses are given in Fig. 152. The material which is best suited for transmission at the wave-length, 2537 Angstroms, is vitreous silica.

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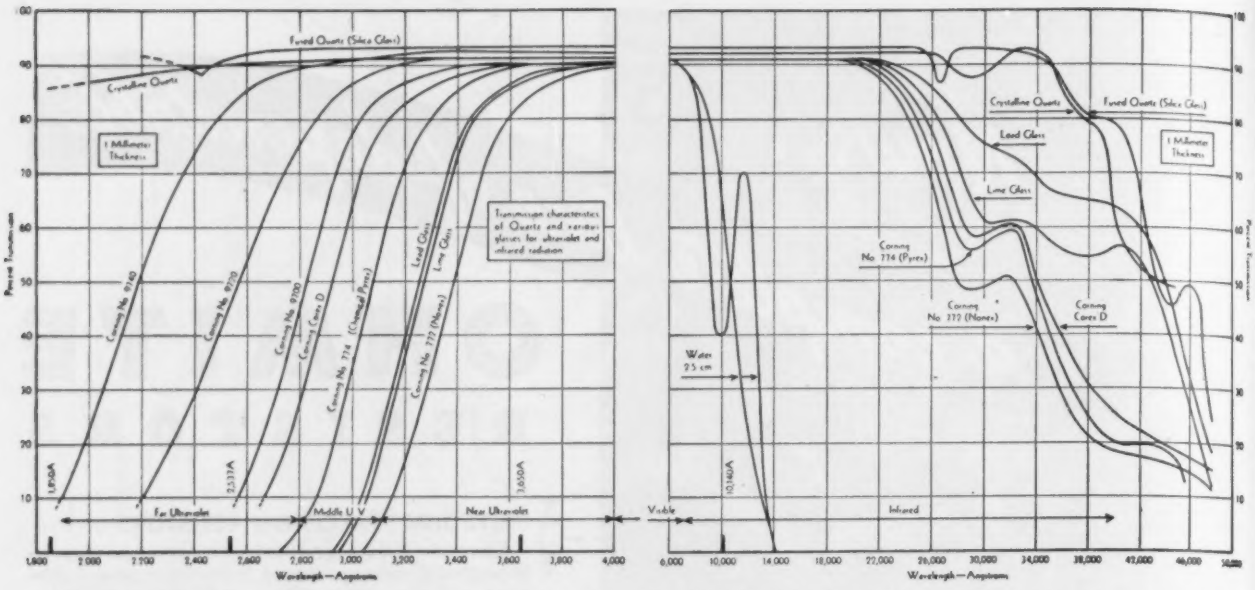

Fig. 152. Transmission characteristics of quartz and various glasses for ultraviolet and infrared radiation. *The data for these curves were furnished through the courtesy of the Research Laboratory of the Corning Glass Works, the National Bureau of Standards and the Lamp Development Laboratory of General Electric Company.*

Production of the Mercury Ultraviolet Lamp

The mercury ultraviolet lamp is made as follows:

1. A coil is made of 10-mm. clear vitreous silica tubing. The Hoke torch with a large jet is used with oxygen and acetylene as fuel to furnish the heat required to shape vitreous silica. A coil of 10 complete turns is made by the method previously outlined.

2. Since it is necessary to make the coil only of vitreous silica and the remainder of the reaction vessel of Pyrex glass No. 774, graded seals must be used at both ends of the coil. It is quite difficult to make a graded seal from vitreous silica to Pyrex glass No. 774 because of the high temperatures that must be used and because the seals between the successive glasses must be thin. The glasses used are vitreous silica and Corning glasses No. 790, 723, 720, 724 and Pyrex glass No. 774 in the order given. Graded seals which can be used for sealing vitreous silica to Pyrex glass No. 774 can be purchased from Corning Glass Works.

The graded seal is sealed to both ends of the coil and the Pyrex glass No. 774 is shaped for the lamp. The procedure for completing the lamp is now similar to that previously outlined for making a condenser. The thermowell is sealed into the jacket after the first ring seal and side tube seal is completed. The second ring seal is completed and the side arm is sealed to the jacket.

3. The preparation of the electrodes in the production of the glass-to-metal press seal will not be given here because it has been discussed previously. The electrode assemblies are sealed to both ends. Standard coated neon sign electrodes can be used; they are quite inexpensive. A tubulation for evacuating the lamp and a small reservoir containing a droplet of clean mercury are sealed to one end of the lamp directly opposite each other and below the electrode seal.

4. The lamp is now ready for evacuation, degassing and filling. It is sealed to a manifold in the position shown in Fig. 150. The lamp is evacuated to the lowest possible pressure along with the manifold and space above the closed capsule of the neon storage tube. The stopcocks above the neon storage tubes are then closed and the capsule is broken by raising the glass-covered iron pellet with a magnet and allowing it to fall. The tube is then filled with neon to a pressure of 20 mm.

The electrodes and the glass tubes of the lamp are now

TABLE 21. RARE GAS COLOR CHART

Color of Tube	*Rare Gas*	*Glass Tubing*	*Mercury*	*Filling Pressure, mm. of mercury*	*Electrodes recommended*
Deep Red	Neon	No. 240	No	6-12	Copper, nickel, iron or SVEA metal
Red	Neon	clear glass	No	6-12	Copper, nickel, iron or SVEA metal
Orange	Neon	No. 353 (Noviol)	No	3-6	Special chemically-treated
Golden yellow	Helium	No. 335	No	3-6	Special chemically-treated
Light green	*argon-neon mixture Linde No. 20 or 70	No. 333	Yes	6-12	Nickel, iron or SVEA metal
Dark Green	*argon-neon mixture Linde No. 20 or 70	No. 353 (Noviol)	Yes	6-12	Nickel, iron or SVEA metal
Light blue	*argon-neon mixture Linde No. 20 or 50	clear	Yes	6-12	Nickel, iron or SVEA metal
Dark blue	*argon-neon mixture Linde No. 70	No. 552	Yes	6-12	Nickel, iron or SVEA metal
White	Helium	clear	No	34	Special chemically-treated

*Argon-neon-helium mixtures must be used when the tubes are subjected to extreme winter conditions.

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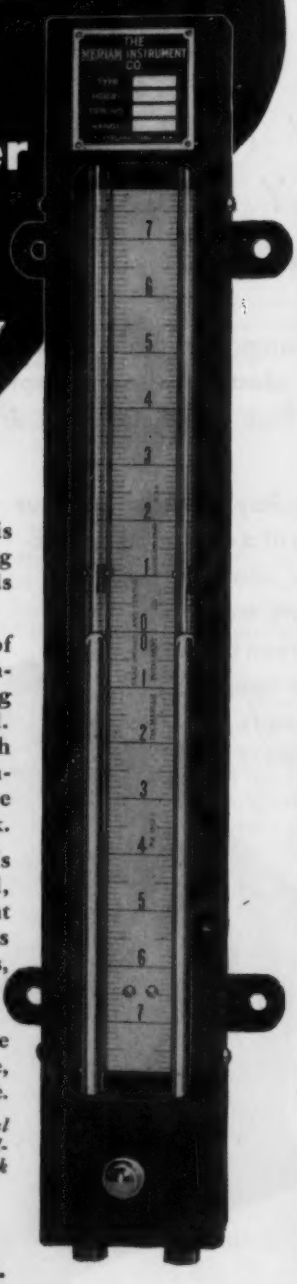

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Fig. 153

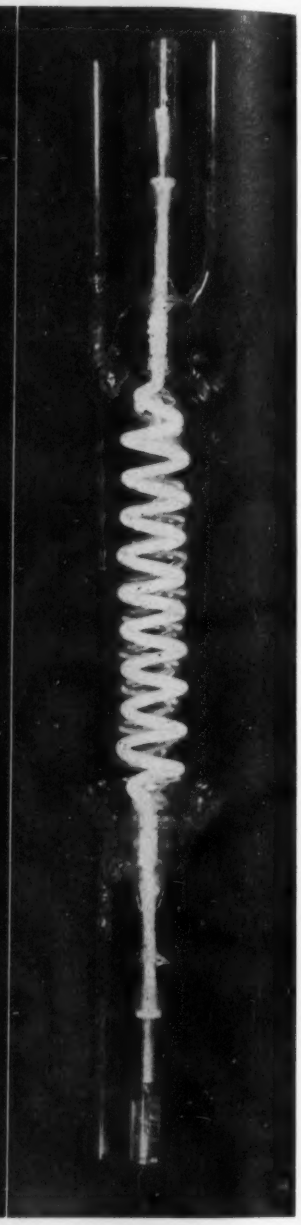

Fig. 154

of mercury. The tubulation is then uniformly heated at the constriction until the glass begins to soften. The tube is drawn away from the manifold as the glass collapses at the constriction. The glass is cut in the burner beyond the center of the closed section and the tip-off is carefully annealed. A drop of mercury is then transferred to the tube and this second tubulation is closed. The finished lamp is shown in Fig. 153. The appearance of the tube in operation with the electrical source mentioned above is shown in Fig. 154.

The intensity of radiation of this mercury ultraviolet lamp can be determined by the photohydrolysis of chloracetic acid. E. Rudberg[19] and Smith, Leighton and Leigh-

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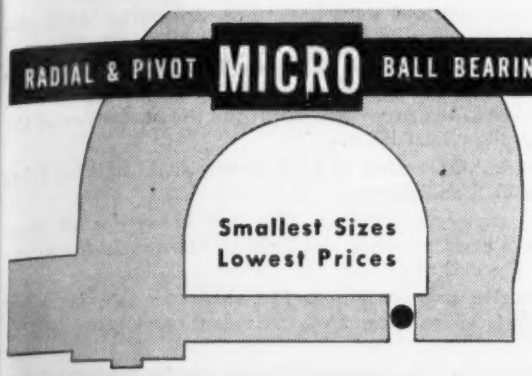

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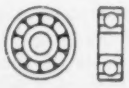

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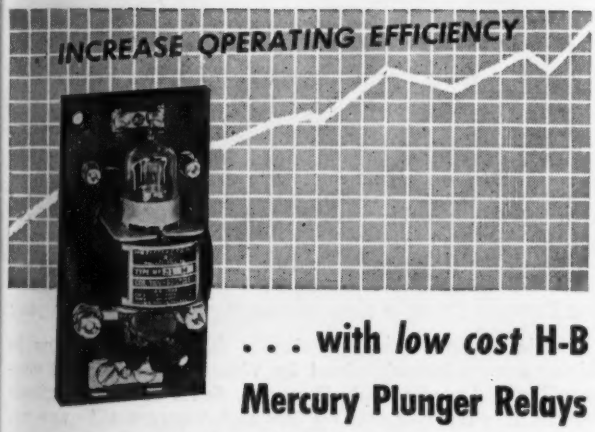

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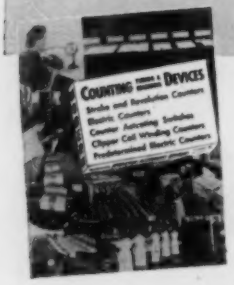

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ton[20] have outlined experiments to determine the photochemical effectiveness of such lamps.

The production of rare-gas tubes for lighting and display purposes will not be given because the techniques involved are similar to the procedure given for the production of the mercury ultraviolet lamp.

In general, according to F. P. Gross, Jr.,[21] lighting tubes are classified as follows:

1. Negative glow lamps. The two electrodes of these lamps are close together and light is emitted from the gas around the cathode.

2. Positive column lamps. The electrodes are far apart and light is emitted from the excited gas molecules between the two electrodes.

Each of these two classes of lamps can be subdivided further into hot- and cold-cathode lamps. The hot-cathode lamps operate at lower voltages.

The colors that can be obtained in display lamps depend upon the gas and glass tubing used. Various shades of green are obtained by the combination of yellow glass and mercury vapor. The rare-gas color chart is given in Table 21. The glasses in Table 21 are supplied by the Corning Glass Works. Gas mixtures refer to the code number of Linde Air Products Company.

A more recent development in rare-gas discharge tubes is the fluorescent lamp. These lamps are produced by coating the inner walls of the tube with chemicals (called "phosphors") which will emit visible light when they are subjected to ultraviolet radiation. The color range of several are given in Table 22.

TABLE 22.
COLORS PRODUCED BY FLUORESCENT COATINGS

Phosphors	*Coating Color*
Calcium tungstate	Blue
Magnesium tungstate	Blue-White
Zinc silicate	Green
Zinc beryllium silicate	Yellow-White
Calcium silicate	Yellow-Pink
Cadmium borate	Pink

The color chart for fluorescent lamps is given in Table 23.

TABLE 23. FLUORESCENT LAMP COLOR CHART

Color	*Gas*	*Pressure mm. Mercury*		*Glass*	*Coating Color*
Rose Pink	Neon	10-18	No	Clear	Blue
Gold	Neon-argon mixture	10-18	Yes	Noviol	Yellow
Yellow	Neon	10-18	No	Clear	Green
Green	Neon-argon mixture	10-20	Yes	Clear	Green
Blue	Neon-argon mixture	10-20	Yes	Clear	Blue
White	Neon-argon mixture	10-20	Yes	Clear	White

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Kinetic systems were previously defined as systems in which vacuum is maintained by virtue of high-speed condensation and mechanical oil pumps. Seals as ground glass-to-glass or glass-to-metal on the high-vacuum side are required, and even though the leakage from such joints may be appreciable, it must not be to the extent that the desired vacuum cannot be maintained. In other applications of the kinetic vacuum system, the high-speed pumps are necessary, because of the degassing that is obtained from the materials in the system as in the case of molecular distillation.

Metallizing of Glass

The use of the kinetic system for equipment production is important in the metallizing of glass. Considerable work in recent years has shown that this process has many applications. Aluminum is one of the metals that can be successfully evaporated. The most practical method of evaporating this metal is by the procedure outlined by J. Strong.[22, 23] A tungsten filament is used. Tests[24] have shown that only about 3% (volume) of tungsten is found in molten aluminum samples when the latter is fused on a tungsten filament. It was also shown that very little tungsten is evaporated, for only 0.03% was found in the alum-

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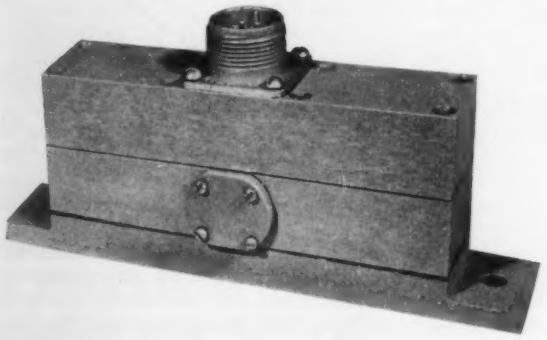

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inum on the glass surface. Actual photographs[25] of the filament during the evaporation process have also shown that the aluminum is evaporated from the tungsten filament adjacent to the molten aluminum, rather than from the molten surface of this metal.

Since mirrors, either opaque or partial, are used in equipment, it will be helpful to outline briefly the procedure for coating glass surfaces with aluminum. It should be pointed out that sometimes considerable experimentation is required before the correct techniques are mastered. A discussion of the vacuum system, glass cleaning and coating techniques will be given as an application of the kinetic vacuum system in equipment production.

The size of the system to be used for metallizing glass surfaces will depend on the size of mirrors to be produced. Small and comparatively inexpensive systems can be built from equipment on hand in the laboratory. Several commercial suppliers (among them Distillation Products, Inc., of Rochester, N. Y., and National Research Corp., of Boston, Mass.) have complete units which can be purchased if it is desirable to set up a permanent metallizing system. A small and simple system can be built with the following equipment:

1. A 12" glass bell jar with a metal base fitted with a 1" vacuum outlet, four insulated and vacuum-tight electrical binding posts, four filament supports, a mirror support and an adjustable shield which can be used to blank out the filament from the mirror. This shield can be supported with a pulley arrangement with an iron counterweight. A permanent magnet is used for lifting the shield prior to the metal evaporation step.
2. Two large cold traps.
3. A mercury or oil condensation pump, with a speed of about 10 to 20 liters/sec. at 0.001 mm. of mercury.
4. A mechanical oil pump, its speed matched with that of the condensation pump.
5. A McLeod gage.
6. A 500-watt transformer with four voltage steps from 4 to 24 volts.
7. An ammeter with a 0-30 ampere range.
8. A voltage transformer. The General Radio Co.'s "Variac" 0-130 volts, rated at 500 watts, is satisfactory.

Arrangement of Vacuum System.—The metal base to the bell jar is anchored to the top of a small table. The vacuum outlet, a 1" Kovar tube, is welded into the metal bell jar base after the glass-to-Kovar seal is made. This line extends through the top of the table. The electrical lines which are connected to the binding posts also extend through the table. A glass cold trap is sealed to the high-vacuum side of condensation pump. A line to the McLeod gage is sealed into this connecting vacuum line. A bleeder line with a 3-mm. bore stopcock is also sealed to this line. The outlet of the mercury condensation pump is connected to the mechanical pump through a second cold trap. This arrangement of bell jar, cold trap, condensation and mechanical pumps can also have a line which by-passes the condensation pump, i.e., a line from the cold trap below the bell jar to the mechanical pump. Large stopcocks (10-mm. bore) are then required to isolate the condensation pump during the initial evacuation and to close the by-pass line when the mercury condensation pump is started.

If an oil condensation pump is used, the liquid nitrogen cold traps are not necessary and the pump can be connected directly to the vacuum outlet line of the bell jar base. In this case it is also convenient to have the McLeod gage and the bleeder lines connected directly through the metal base of the bell jar.

The Tungsten Filament.—The 20-mil tungsten wire should not be brittle. When the filament is purchased it should be specified that the wire should be soft enough so that it can be wrapped around its own diameter. The location of the filament coil or loops containing the aluminum will depend on the size and shape of the proposed mirror backing. P. Bonet-Maury[26] found that when polonium was evaporated in high vacuum, it condensed on a plane surface

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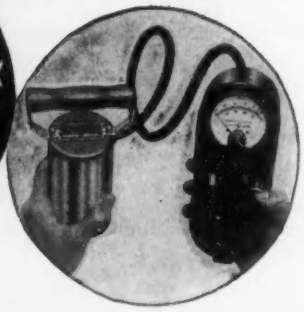

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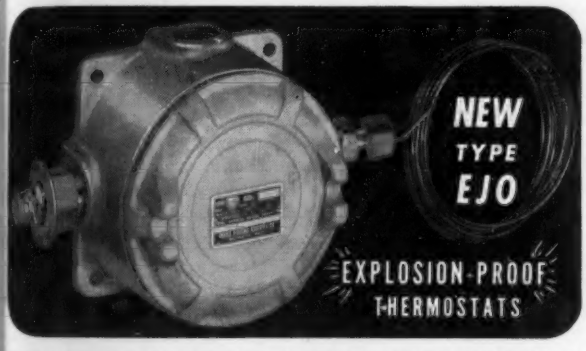

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in an amount proportional to the inverse square of the distance from the evaporation point. J. Strong[27] assumed that other metals behaved in the same way and gave the following equation for film thickness when metal is evaporated from a point source to a plane surface:

$$\tau_P = \frac{m}{4\pi d r^2} \text{ cosine } \theta \qquad \ldots \quad 27$$

where τ_P = the film thickness
m = mass of metal evaporated
d = the density of the metal
r = distance from source to the condensation surface
θ = inclination angle

The evaporation points can be so arranged that a uniform aluminum film thickness can be obtained on the mirror base. This is especially desirable when partial mirrors are produced. Filament spacing for the production of circular mirrors is given by J. Strong.[27]

Cleaning Glass. — The two essentials for preparing the glass for aluminizing are that it must be *clean* and *dry*. Procedures for cleaning glass have been given by J. Strong[28] and V. Vaud.[29] A satisfactory method used in this laboratory is as follows:

1. The glass is thoroughly washed in a solution of distilled water and the commercial detergent "Dreft."

2. The glass is cleaned by dipping it into cleaning solution (sodium bichromate dissolved in sulphuric acid), then rinsed with distilled water.

3. The glass is then rubbed with a cotton swab which has been dipped into a mixture of a 1% solution of Aerosol OT and precipitated chalk. Optically-ground surfaces should not be treated in this manner because of the possibility of scratching the glass surface.

4. Step No. 2 is repeated and the glass is left in distilled water (not more than an hour). It is important not to pile the glass pieces on top of one another while they are in the water.

5. The glass is washed in two successive baths of absolute ethyl alcohol. It is dried with lens tissue or a silk handkerchief which has been rinsed in chemically pure benzene and allowed to dry completely.

Production of Opaque Mirrors. — Opaque mirrors are made as follows:

1. The point source or sources for the evaporation of aluminum will depend on the size and shape of the glass which is to be coated. Calculations for aluminum film thickness can be made by using equation 27. The evaporation sources can then be located from the calculated results.

2. The tungsten filament is cleaned with crocus cloth and small loops are bent in the filament at the required points. The filament is then fastened to the filament holders by small set screws.

3. Aluminum foil, sufficient to give the required film thickness, is then folded over the loops in the tungsten filament.

4. The clean and dry glass is placed on the holder and the shield is placed over the glass. The glass bell jar is then set into position and the outside edges of this jar are sealed with Apiezon grease No. Q.

5. The system is then evacuated with the mechanical pump until the pressure is 0.01 mm. of mercury. The cold traps are then partly immersed in liquid nitrogen and the condensation pump is started. The system is pumped until the pressure is 10^{-5} mm. of mercury. The cold traps are then totally immersed.

6. The aluminum foil is fused to the tungsten filament while the shield is over the glass. The voltage transformer is turned up slowly in this operation until the ammeter reads 10 amperes.

7. The shield is then removed by lowering the iron counterbalance with a permanent magnet. The filament is then flashed at 12 to 18 amperes from 10 to 30 seconds.

8. The vacuum is broken by slowly opening the bleeder stopcock after the condensation and mechanical pumps are stopped.

Partial Mirrors.—Partial mirrors, which reflect as well

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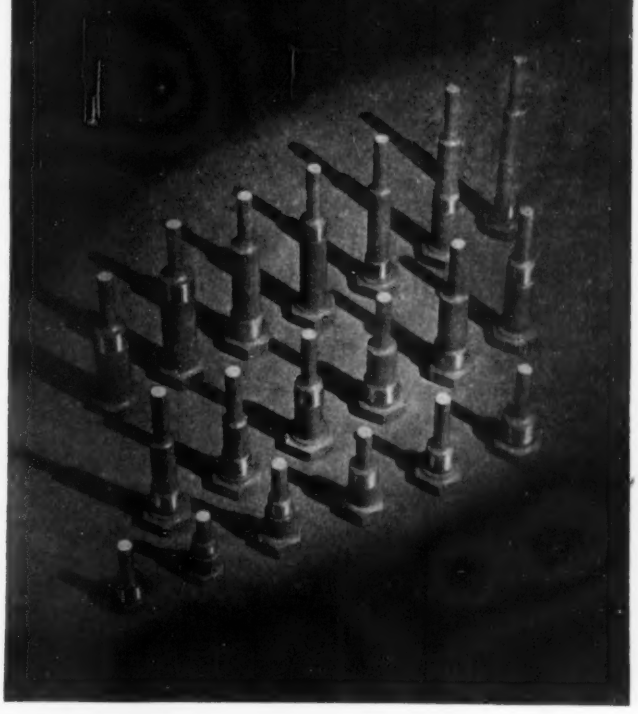

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as transmit light, are used in interferometers and certain other optical systems. These mirrors are made by controlling the amount of aluminum which is deposited on the mirror base. In this case it is even more important to locate the evaporation point sources. This can be done by calculation as outlined in the production of opaque mirrors. An outline for the production of partial mirrors is as follows:

1. The filament is fastened to the filament supports. The filament loop or loops are located according to the above calculations.
2. Aluminum foil, 5 mm. square, is then placed on the filament loops. The bell jar is closed and the system is evacuated until the pressure of 10^{-5} mm. of mercury is obtained.
3. The aluminum is then completely evaporated from the tungsten filament. If the filament is watched in the operation, it will be possible to see when the aluminum is all evaporated because the filament will also begin to glow at the point where the aluminum was located.
4. The vacuum is then broken and the bell jar is removed. The clean and dry mirror base is placed on the holder and the weighed amount of aluminum is placed on the filament loops.
5. The bell jar is then replaced, sealed and the system is evacuated.
6. The aluminum is then evaporated to the mirror base.

It is very difficult to reproduce partial mirrors. If sufficient data are accumulated on reflectivity or transmission obtained from evaporating different weighed amounts of aluminum, it is not hard to reproduce mirror transmission within 5 percent.

The oxidation of the aluminum film will also change the characteristics of the partial mirror. Mirrors which give a transmission of 16% to 18% and 43% to 45% when first produced, will give a transmission of 20% and 50% respectively, after the aluminum film is oxidized.

To be continued

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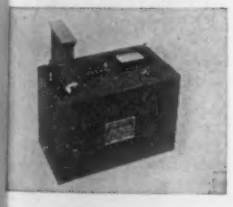

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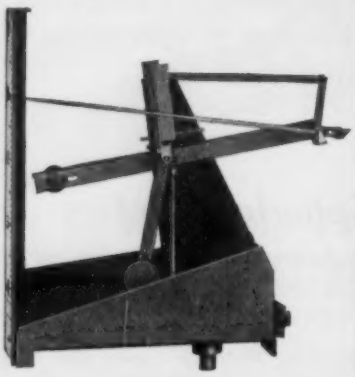

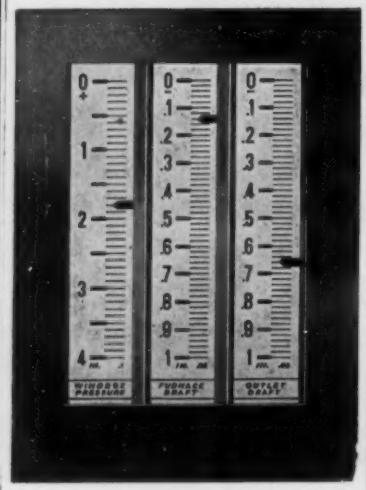

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INSTRUMENTS ON THE MARCH

New Thermocouple Assembly for Gas Turbines and Jet Engines

WASHINGTON, D. C.—With the recent development of gas turbines and jet engines as practical power plants has come a need for accurate and rapidly-responsive temperature-measuring instruments—not only for evaluating engine efficiency but also for protecting experimental and service equipment against damage. An improved pyrometer for measuring the temperatures of these high-temperature high-velocity gas streams has been developed by Andrew I. Dahl at the National Bureau of Standards in coöperation with the Bureau of Ships, Navy Department.

The new pyrometer is not a complete measuring system but a thermocouple assembly—a junction around which is pressed a small, light, silver shield. The main problem in measuring the temperature of the hot gases is preventing the transfer of heat to or from the thermocouple junction by radiation. The shields formerly used for this purpose are not only bulky, and slow to respond to changes in temperature, but also offer considerable obstruction to the gas stream. The use of a silver shield overcomes these limitations since silver, being a good reflector and a poor emitter for radiant heat energy, keeps the temperature of the shielded junction nearly the same as that of the gas. The new device was found accurate to within 5°F. in experiments utilizing a stream of gas at 1500°F. flowing with a veloc-

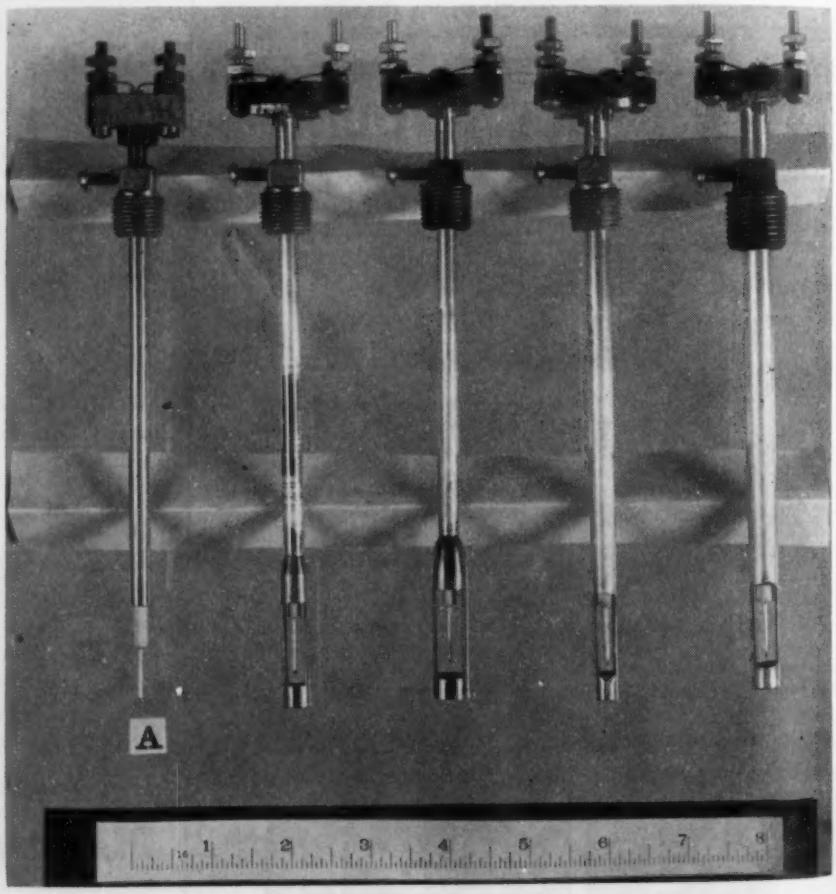

Fig. 1. Five types of rapidly-responsive steel-protected thermocouples utilizing silver-shielded junctions developed at the National Bureau of Standards for use in the current developments of gas turbines and jet engines. In addition to high accuracy, laboratory tests indicate that these assemblies are simple to construct and easy to install. The new type junction creates a minimum of disturbances to gas flow. The guarded junctions give substantially the same results as the unguarded type A.

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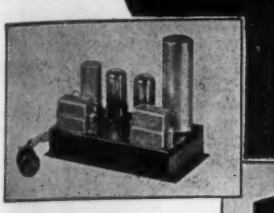

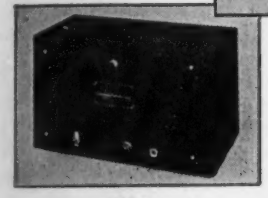

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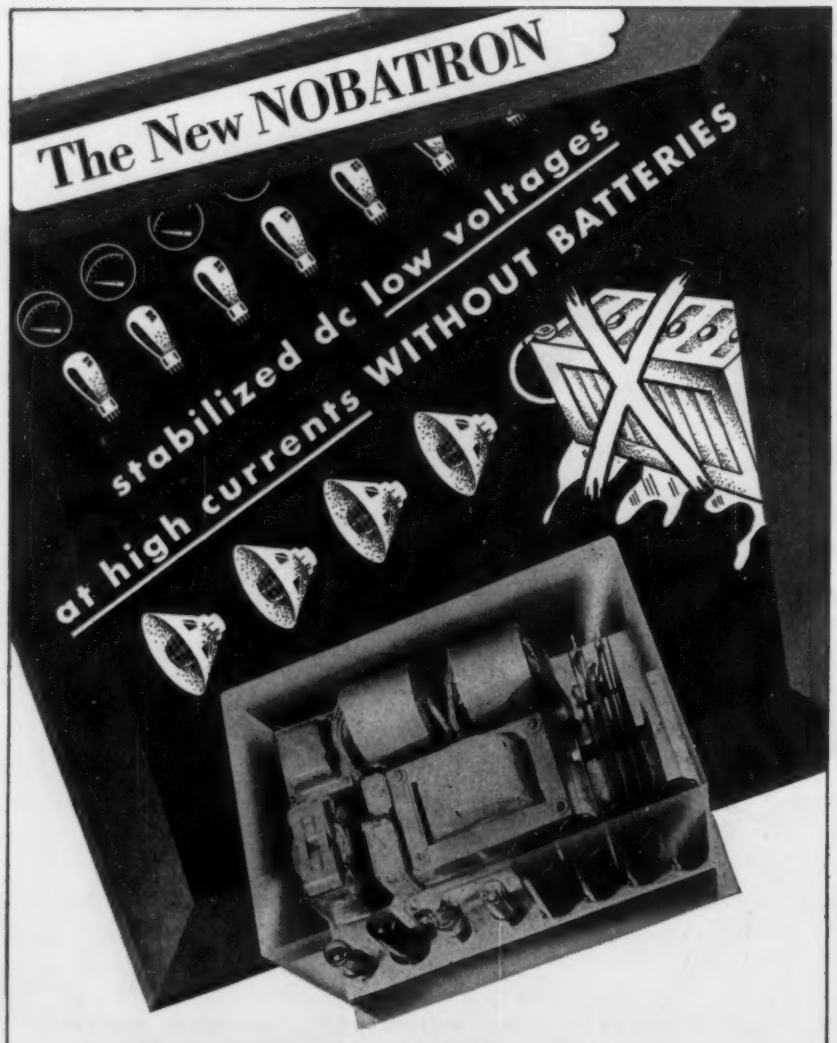

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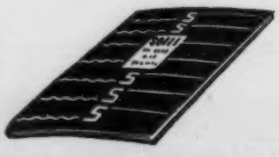

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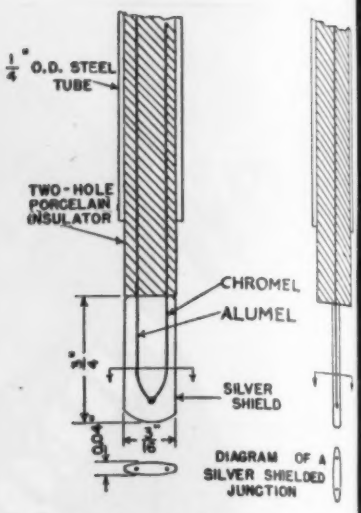


Fig. 2. Schematic diagram of a silver-shielded pyrometer junction of the type developed at the National Bureau of Standards. The junction, made by conventional methods, is inserted ½" into a silver tube ¾" long that is slightly flattened. A thin mica strip is inserted within the silver tube on each side of the junction and the assembly is pressed to form a rigid unit with good thermal contact between shield and junction. The maximum width of the completed shield need not exceed the diameter of the porcelain tube used for insulating the thermocouple wires from each other.

ity at 250 fps. through a pipe wit walls at 1200°F. In addition to hig accuracy, laboratory tests indicate tha this thermocouple responds quickly t changes in temperature, is simple t construct and easy to install, and tha the new junction creates a minimum o disturbance to gas flow.

The maximum dimension of the shield ed junction need not exceed the diam eter of the porcelain tube used to insu late the thermocouple wires from eac other. Various types of steel protectin tubes can be used to protect the uni without loss of accuracy or sensitivity Several of the new instruments hav been constructed and sent to commer cial turbine manufacturers for servic tests in full-scale operating turbines.

Fatigue-testing by Acoustic Resonance

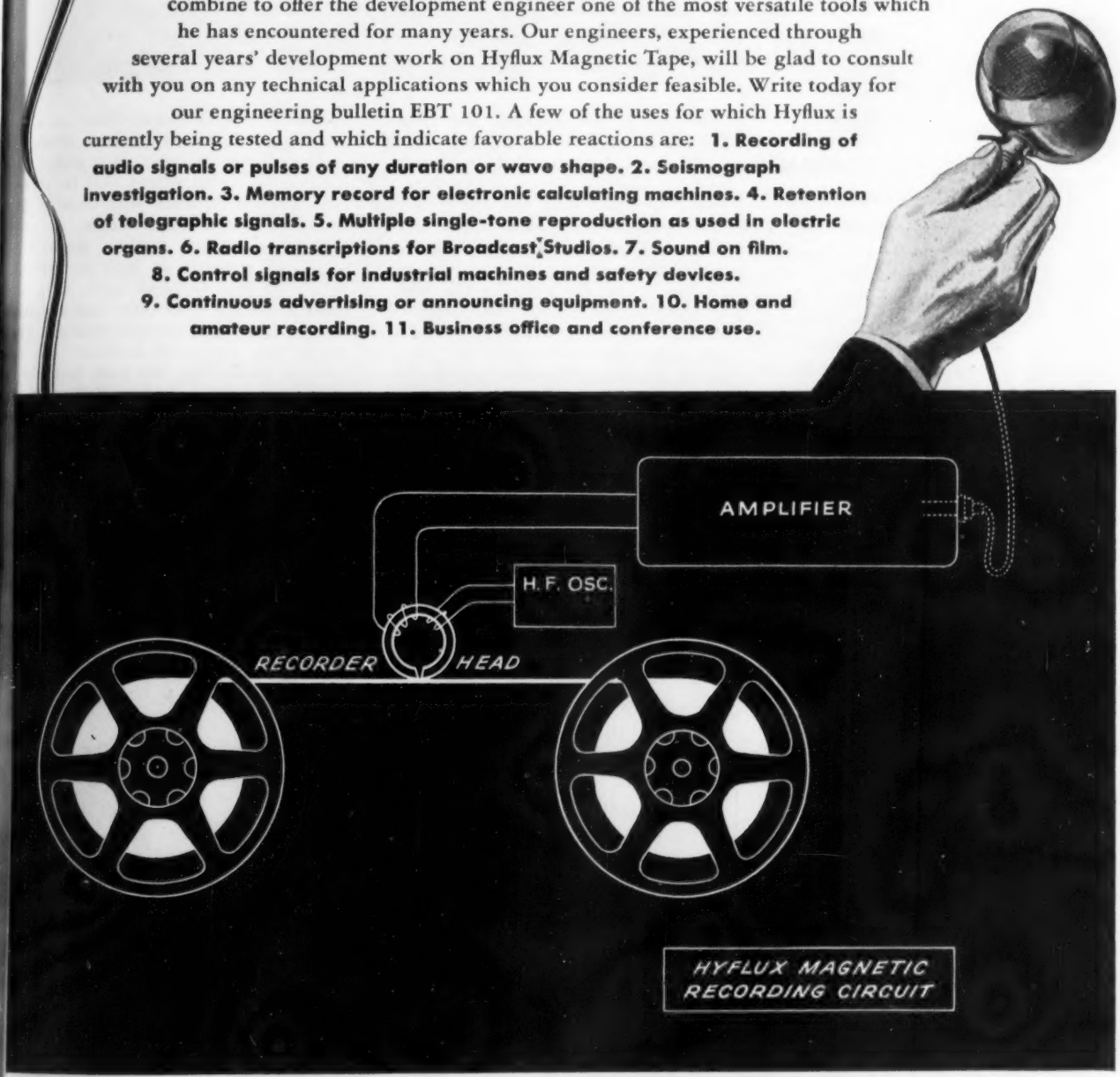
SCHENECTADY, N. Y.—A pneu matically-operated fatigue testing ma chine, whose operating principle is simi lar to that of a slide trombone, wa described by its developer, F. B. Quin lan of the Schenectady Works Labora tory of the General Electric Co. at th recent Buffalo meeting of the Amer ican Society for Testing Materials.

Originally developed to test gas tur bine buckets, the device has proved so efficient and adaptable that it will un doubtedly have wide industrial appli cations, Mr. Quinlan said.

The operating mechanism of the new instrument is extremely simple, consist ing of a tuned air column in which the tuning is accomplished by decreasing the length of the air path, much as

Hyflux Links Electronics and Mechanics

The new Hyflux magnetic tape has changed sound recording from a mechanical operation to a combined electronic and magnetic circuit with mechanical driving mechanism to attain unexcelled reproductive quality. The elimination of mechanical noise inherent in previously used sound recording techniques is a major factor in the utility and flexibility of this new medium. Permanent magnets have been useful for many years in the field of sound in transforming mechanical energy into electrical energy, but the introduction of Hyflux, which is a finely divided magnetic material, establishes a new transformation—that of electrical-to-magnetic-to-electrical energy. The result is a high-fidelity, noise-free, continuous recording adaptable to a wide field of application. Features of instantaneous and repetitious erasure, visual and audio editing, as well as permanency attributable to the high coercive force of the magnetic material, and durability due to the choice of paper used combine to offer the development engineer one of the most versatile tools which he has encountered for many years. Our engineers, experienced through several years' development work on Hyflux Magnetic Tape, will be glad to consult with you on any technical applications which you consider feasible. Write today for our engineering bulletin EBT 101. A few of the uses for which Hyflux is currently being tested and which indicate favorable reactions are: **1. Recording of audio signals or pulses of any duration or wave shape. 2. Seismograph investigation. 3. Memory record for electronic calculating machines. 4. Retention of telegraphic signals. 5. Multiple single-tone reproduction as used in electric organs. 6. Radio transcriptions for Broadcast Studios. 7. Sound on film. 8. Control signals for industrial machines and safety devices. 9. Continuous advertising or announcing equipment. 10. Home and amateur recording. 11. Business office and conference use.**



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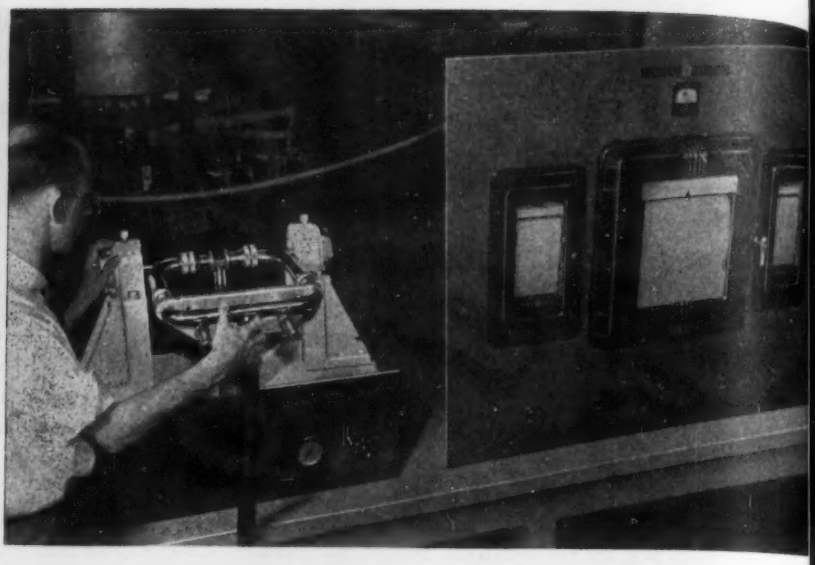


trombone player changes the tone of his instrument by moving the slide.

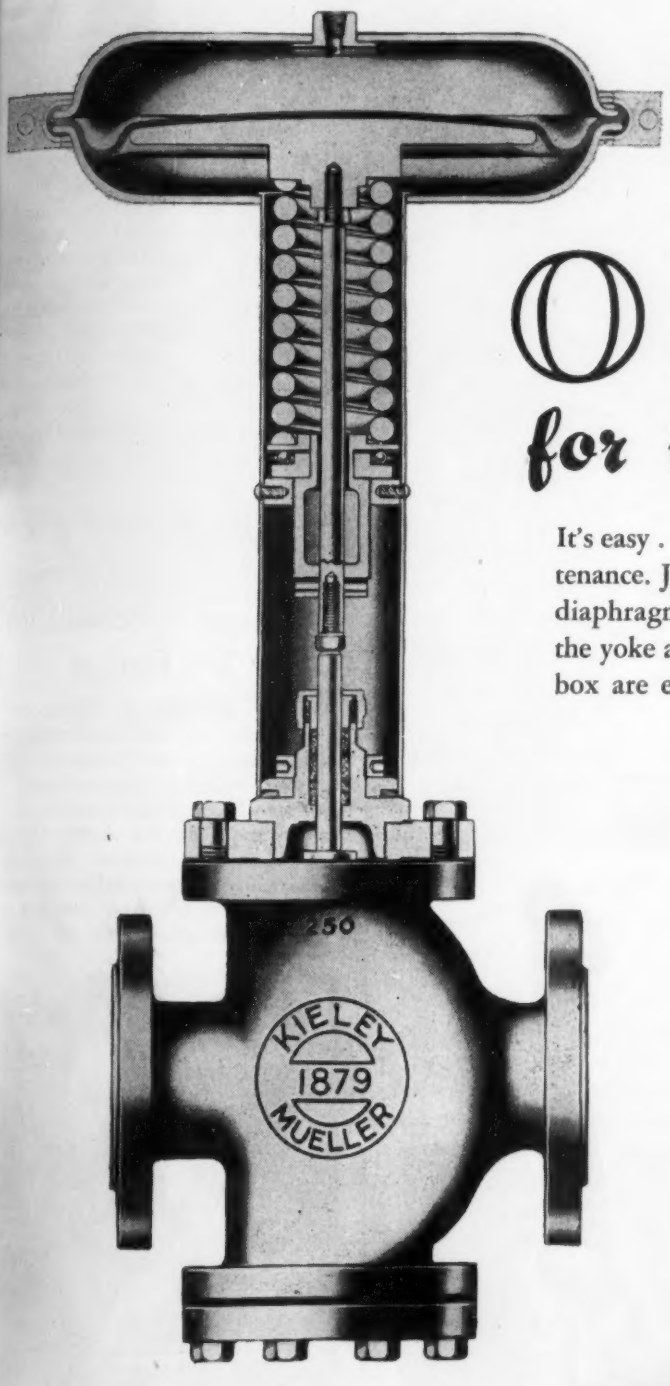
The part to be tested is placed in such a position between the two air paths or tubes that the air from the open ends strike on the upper end of the sample piece, setting it to vibrating. Since the piece vibrates at the same frequency as the note in the testing trombone, and air is continually fed through the tubes, the air impulses will cause continuous vibration of the test piece. Adjusting the tube length so that the air in them vibrates at the same frequency as that of the test sample makes it possible to produce very large and stable amplitudes of vibrations with comparatively small amounts of air.

The sample vibrates, of course, until it fatigues to the extent that its vibrations are out of phase with those of the tuned air and a break occurs.

The pneumatic fatigue tester has produced stresses as high as 100,000 lbs./in.^{2}, Mr. Quinlan said, with no more air being used than that supplied by the average vacuum cleaner. The tester has no parts to wear out, as nothing moves but the part to be broken. Three different models have been built, the one described, one that has proved especially efficient for torsion

UAL Instrument Shop Personnel Safeguarded Against Radioactivity

Col. A. D. Tuttle, United Air Lines medical director, demonstrates to company's medical staff features of new Geiger-Müller counter for the detection of radioactive material. United uses the instrument to safeguard employes in its Cheyenne and San Francisco instrument shops and other points where radium paint is used or wherever metal filings are dumped. Left to right: Dr. G. J. Kidera, United's regional manager of medical service, Chicago; Dr. A. C. Ladd, regional manager of medical service, San Francisco; Col. Tuttle; Dr. W. A. Bock, assistant to medical director, Chicago; and Dr. L. C. Benesh, regional manager of medical service, Cheyenne.



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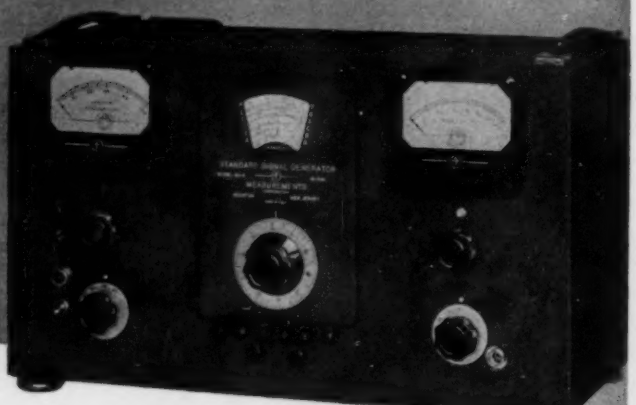

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testing, and one for strip testing. All of them operate on the same principle, but differ in size and arrangements for holding the piece to be tested. With the exception of the strip fatigue machine, all parts may be tested at temperatures from below zero to 1700°F.

Current research with the pneumatic tester is providing preliminary data which indicate that by using a recording frequency meter, the chart will show what appears to be a point of incipient failure. These data, of course, are extremely valuable to the designer and engineer. Brittle materials show this point of incipient failure to be very close to that of complete fracture, the author pointed out in conclusion, but in ductile materials it appears long before visible fracture becomes apparent.

New Radio-telemetering and Automatic-control Systems Successful in V-2 Firings

WHITE SANDS, N. M.—A new 15 lb. telemetering system, developed by General Electric and designed to track rockets speeding at approximately 3600 mph, was successfully tested in the V-2 missile firing at the Army Ordnance Proving Ground here on January 23. The system automatically transmitted 28 items of information every 1/35 of a second. Measurements of accelera-

Walter Hausz, head of the Guidance and Control Group of the G-E guided-missile research program for the Army Ordnance Dep't, adjusting the 15-lb. telemetering and gyro control system used in the firing of the V-2 rocket at W.S.P.G. Dr. Hausz visited England, France and Germany in 1945 to inspect radio-telemetering systems developed in those countries.

Here's a new way to read meters ...in the dark!

How often have you wished for a meter you could see *clearly*—the whole scale of it, wherever you were using it—in the dark, under low lights, or even in the kind of glare that causes reflections on the glass—a really illuminated meter? Well, here it is—the result of a new Simpson patented method of illumination.

On these new Simpson Illuminated Meters (voltmeters, ammeters, milliammeters, and microammeters), every fraction of the dial face is flooded with light—there isn't a spot of shadow. And this isn't a dull glimmer of light. It's a full and even radiance.

An ingeniously shaped Lucite cone carries the light from a recessed bulb in the back of the instrument through the front edge that surrounds the entire dial. This makes possible the use of the standard Simpson metal dial. Unlike translucent dials, it cannot fade or discolor so that reading becomes difficult. It cannot warp or buckle, causing the pointer to stick, or distorting readings. The bulb recess is neoprene sealed.

Behind the refinement of this superior illumination lies the basic reason for preferring Simpson instruments—their in-built accuracy. That high quality which is the indispensable component of every Simpson instrument makes sure that the accuracy will *stay* there, year after year.

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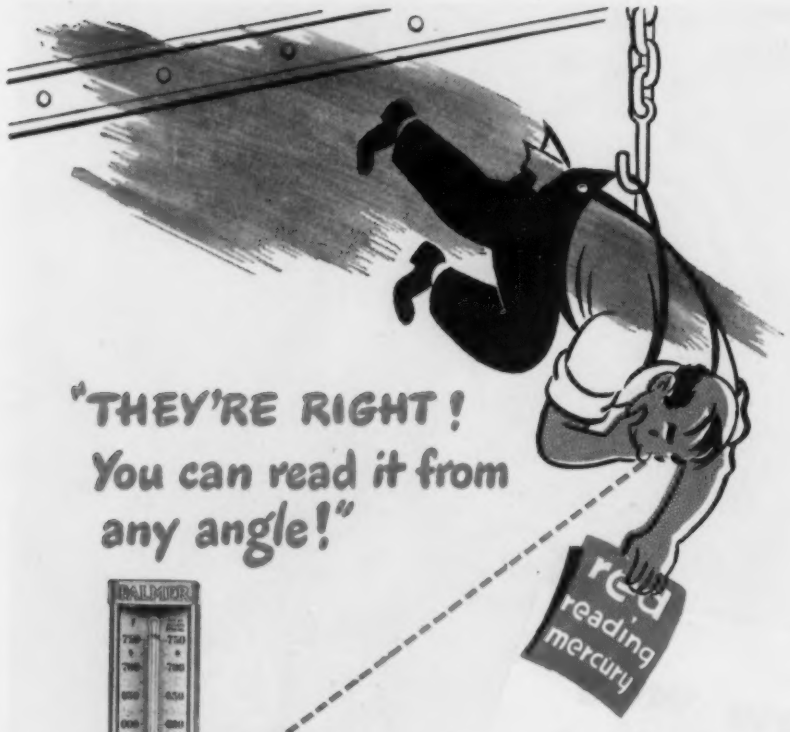
2" Rectangular Case. 2-3/8" square. Mounts in round hole. Body diameter, 2-3/16".



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AND REMEMBER—specify this new thermometer on original equipment purchased from your jobber or equipment manufacturer — there should be no extra charge!

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tion, position of control vanes, fu pressure, rocket skin temperature a other factors were received at t ground station and permanently re corded on films by automatic motio picture cameras.

Less than one-sixth the weight previous telemetering devices, the G- system uses only ten electron tubes compared to the thirty tubes in a sim lar system. Enclosed in the rocket wa head, the new missile-borne unit packaged in two pressurized cans, ea 4" in diameter and 12" and 15" lon Power is supplied by a separate 28-vo battery, located in the control compar ment, which weighs 12 lbs.

Since the system is mechanical

Dr. Lewis J. Neelands, G-E engineer, adjusts the antennae used for receiving information from the telemetering and gyro-control system in the warhead of the V-2 rocket fired on January 23 at W.S.P.G.

commutated, each of a number of co ditions of interest must be converte to a voltage that varies between ze and +5 volts and must be connected one segment of a stationary commu tator. Twenty-eight such channels a provided and a rotating brush sampl each of these 35 times per second. The samples of voltage are converted pulse-width modulation; i.e., a ze voltage input to one channel is co verted to a 50-microsecond pulse, whi a five-volt input is converted to a 65 microsecond pulse. A five-watt tran mitter sends this signal to the groun

At the receiving station a line sweep on a cathode-ray oscilloscope triggered by the leading edge of ea received pulse. The incoming signal put on the intensity grid so that a lin whose length is proportional to the mag nitude being measured, will appear the 'scope. The film records while mov ing steadily in a vertical direction. A

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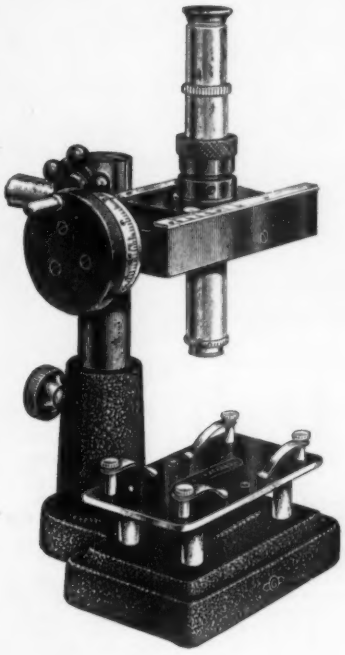

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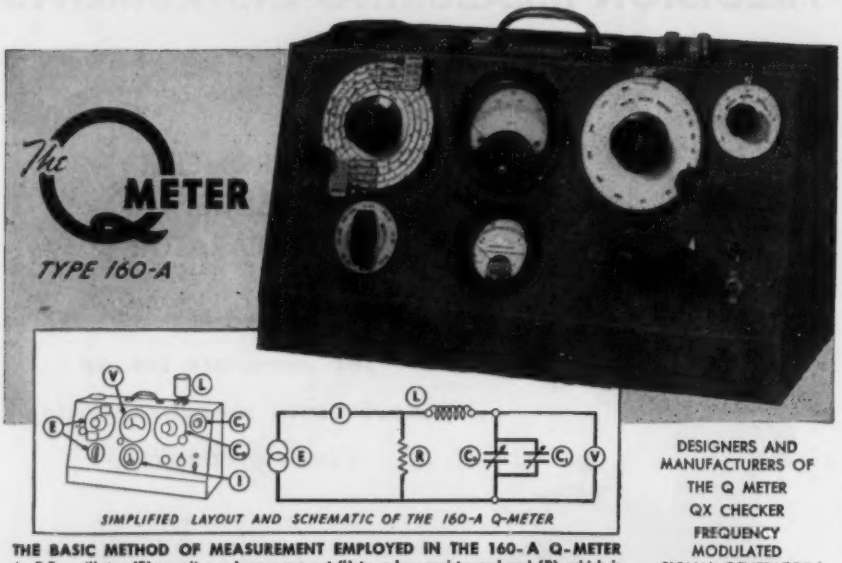

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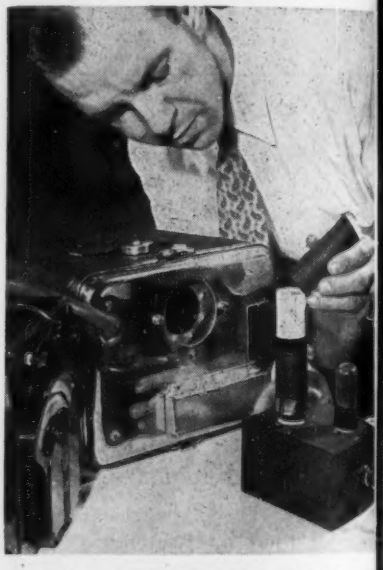
the samples on all the channels wi appear as parallel lines of varyin length. Thus, one rotation of the com mutator, or one sample of each channel is represented by a block of 28 parall lines. The over-all error, counting al the transformations from the original magnitude to the final record, is only about 2% to 3%.

A new G-E gyro steering-control sys tem was also tested in this flight. Ca pable of controlling the flight of th missile right and left, as well as u and down, the system operated in re sponse to command signals given by timing device located within the rocket Information regarding the operation o this gyro steering-control system wa transmitted to the ground through tele metering channels.

Instrument Counts X-ray Quanta

PITTSBURGH, Penna. — Develop ment of an electronic x-ray counte that accurately records x-rays at mil lionth-of-a-second speed over a wid range of intensities has been announced by Dr. Fitz-Hugh Marshall and Dr John W. Coltman, Westinghouse re search engineers.

First all-purpose tool for the meas



A white fluorescent "vest" and black pape "coat" are necessary items of attire for the super sensitive photomultiplier tube that plays the ke role in the new x-ray meter. Dr. Fitz-Hugh Mar shall, Westinghouse research engineer, is shown placing the black paper over the white fluorescent screen which surrounds the tube.

urement of x-radiation, this x-ray de tector in high-speed tests has ap proached the ultimate in sensitivity by providing exact measurement of the smallest x-ray units known (individual quanta) as well as intense radiation.

The difficulty of measuring x-rays al ways has been a scientific headache, ac cording to Dr. Marshall. The Geiger-

OF COURSE, it can't be stopped by a human skull—no matter how thick. But exposure must be held within strict limits . . . for X-ray treatment as well as photography. That can be done easily and *accurately* with a modern X-ray machine when it has a timer operated by a Telechron synchronous electric motor.

This is typical of hundreds of applications for these dependable, versatile motors. For over 25 years Telechron has been the largest producer of synchronous electric motors. Telechron engineers—co-operating with the manufacturers of automatic timing, switching, recording, and control equipment—are working out new applications every day. *Perhaps they have the answer to the timing puzzle confronting you.*

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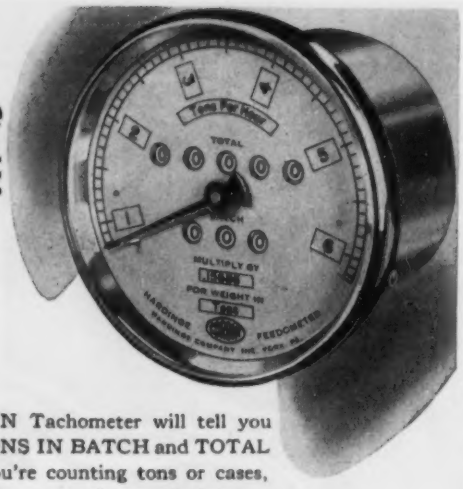

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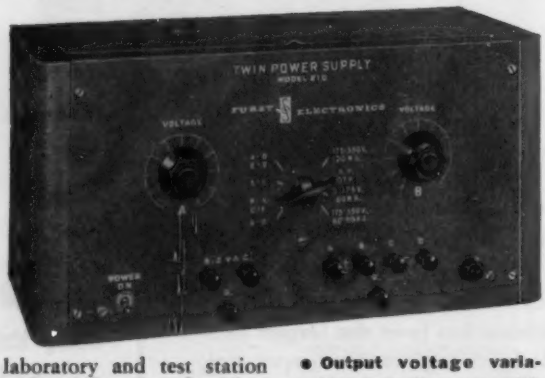

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Müller counter of the type used Bikini to warn of radioactivity mea ures only low intensities of radiati Development of such a highly sensiti and versatile instrument as this n counter, therefore, gives science a va able tool for fundamental research well as pointing the way to possible f ture industrial applications of x-r equipment.

Dr. Marshall explains the device an adaptation of the photomultipli an already existing type of electron tube which was found to have "unsu pected talents." Extremely simple in construction, the new instrument co sists of a photomultiplier tube wrapp in a sheet of fluorescent screen wh is itself wrapped in black paper. Wh the black paper blocks out all ro light, x-rays penetrate to the fluor cent screen. The tube measures the i tensity of this fluorescence and can r cord changes in intensity as rapidly one every millionth of a second.

In high-speed tests, the new detec has approached the ultimate in sensiti ity by responding to individual quan of x-radiation. Never before has s ence had a satisfactory all-purpose t for measuring x-radiation. Heretofo the most widely used instrument measurement has been the ionizati chamber. Unfortunately, however, t ionization chamber is something of prima donna: when used at high sens tivity it is so unstable that the ele tricity generated by a man combing h hair within ten feet of the instrume upsets the measurement. The fact th the ionization chamber requires days work to construct and very careful ha dling to operate limits its usefulne

Pitt Cyclotron Unique i Function

PITTSBURGH, Penna. — The Un versity of Pittsburgh's 20-million-v cyclotron is now producing radioacti elements vital to medical research a opening new horizons in nuclear phy ics. Buried in a hillside on the Univer sity campus, the 100-ton instrume will be geared with medical scienc new attacks on cancer and leukemi with research into the secrets of anim and plant growth, and with industri research in metals, chemistry and glas Equally important, it will probe st deeper into the atom.

The Pitt cyclotron, third largest i the world, is a coöperative project Pittsburgh's civic, educational, and in dustrial institutions. Grants of $82,50 jointly from Mrs. Alan Magee Scaif and the Sarah Mellon Scaife Founda tion made possible the construction an six local firms contributed equipmen and materials. The cyclotron was buil under the supervision of Dr. Alexande J. Allen, Westinghouse Graduate Pro

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fessor of Engineering at the University of Pittsburgh.

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The present building was completed in 1942, but installation of the machine was delayed by the war. The coöperating firms are Westinghouse Electric Corp., Gulf Oil Corp., Aluminum Company of America, Carnegie-Illinois Steel Corp., Mesta Machine Co. and General Electric Co.

Instrumentician Heads NBS Atomic-physics Section

WASHINGTON, D. C.—Dr. John A. Hipple, 35-year-old physicist, who is one of the world's outstanding authorities on the design, construction and use of the mass spectrometer, has been appointed chief of the Atomic Physics Section at the National Bureau of Standards, Dr. E. U. Condon, Director of the Bureau, has announced. Dr. Hipple will direct research on the ionization and separation of molecules by electron impact; also an extensive program measuring the masses of the elements and their isotopes, using mass spectrometers to be designed by him. Dr. Hipple joins the Bureau staff from the Research Laboratories of the Westinghouse Electric Corp. where he has been section manager in the electrophysics division. The mass spectrometer which he helped develop while at Westinghouse found many applications in industry as well as in science. During the war he acted as a Westinghouse consultant on atomic physics. Dr. Hipple received his bachelor of science degree from Franklin and Marshall College in 1933, and his doctorate from Princeton in 1937. From 1934 to 1938 he was a research assistant in mass spectrometry at Princeton.

CORRECTION

In "Control of Reactors for Synthetic Rubber" by Dr. Rowland (March issue, pages 136-138, the captions of Figs. 7 and 8 were transposed. The figure *numbers* are right but the *wordings that* follow should be interchanged.

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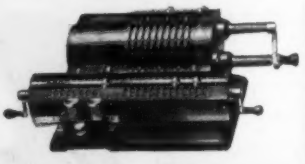

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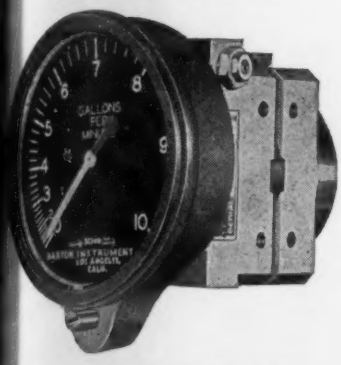

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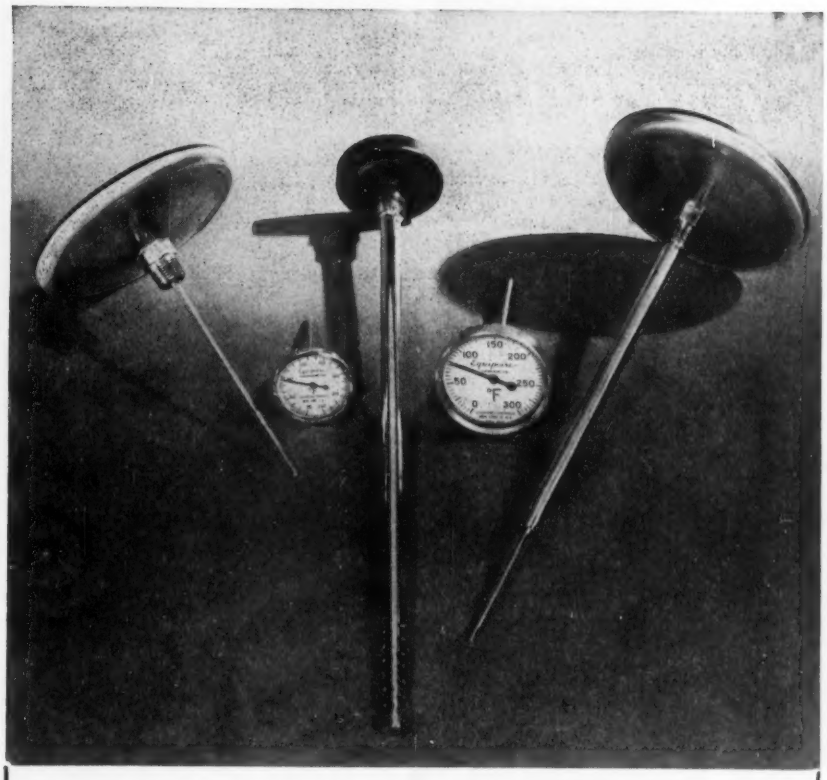

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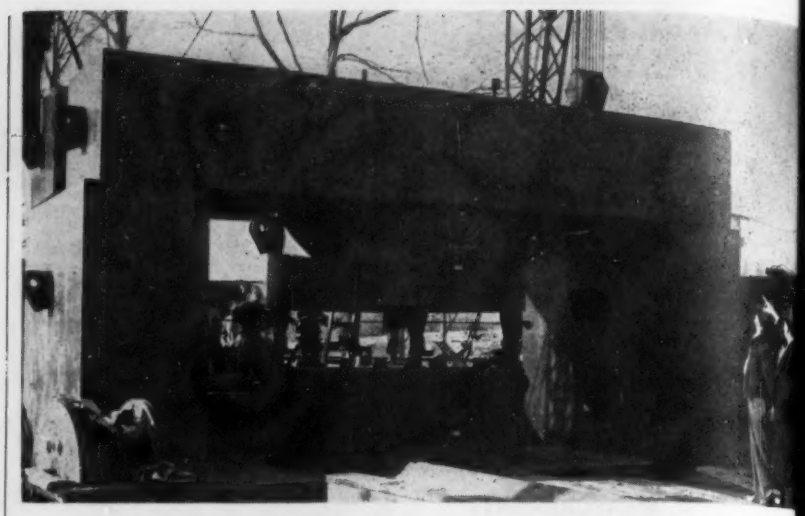
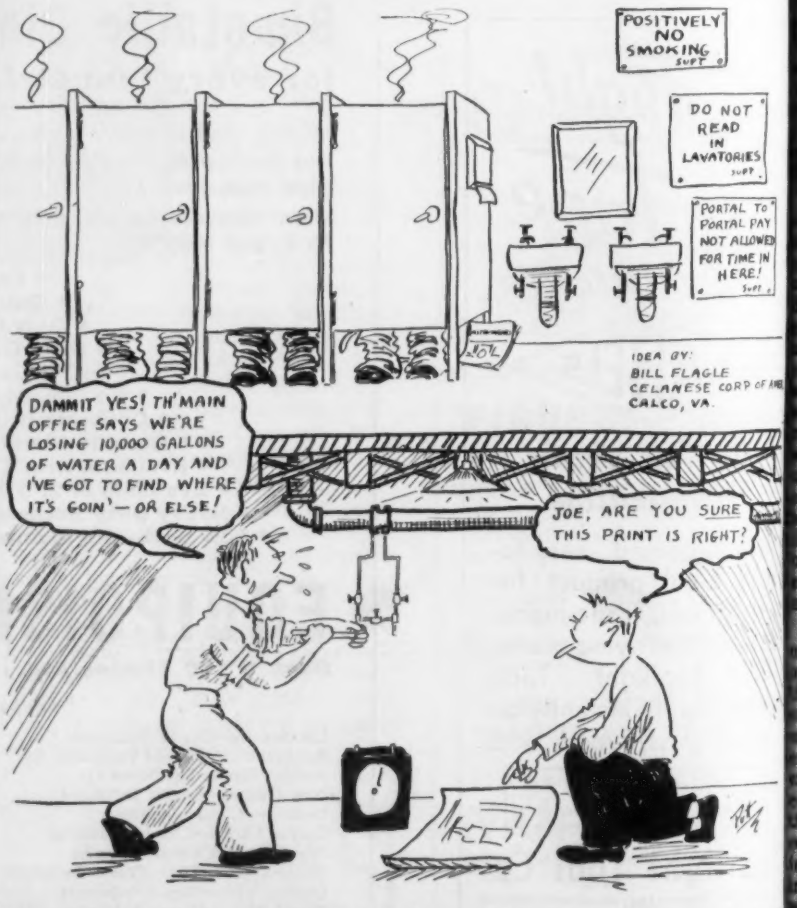


Instrument Magnets Come in Large Sizes, Too.

PITTSBURGH, Penna.—Here is shown the assembly of eight solid steel forgings, weighing an average of 150 tons each, to form the magnet of a cyclotron for the United States Navy's radiation program at University of Rochester. Eight full heats of open-hearth steel were cast and formed at Homestead Works of U. S. Steel's Carnegie-Illinois Steel Corp. in the construction of the magnet. Dr. Sidney W. Barnes, Rochester professor of physics, second from right, is in charge of the project.

WHEN A FELLER NEEDS CONTROL BY Putt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JOURNAL of the Instrument Society of America

Editor, R. R. PROCTOR, 2213 Ridge Ave., Evanston, Ill.

Vol. 2 MARCH 1947 No. 3

Editorial

MAN INSTRUMENTS

We have many times watched a gentleman of our acquaintance, an electrician by trade, make what to us were medal checks on various electrical systems, particularly at the distribution panels. On a recent occasion, as on many past occasions, a power failure brought him to the scene of our activities, and we watched him try to determine which leg of a 240-volt 3-phase circuit was dead, and why. Disdaining the use of a test lamp and a voltmeter which were both near at hand, he held one finger of his left hand on the steel cabinet, then used one finger of his other hand to nonchalantly touch in turn each lug of three 600-ampere fuses! He immediately identified a dead fuse, of course, because he "didn't feel nothin' at one end."

However, he wasn't satisfied in just knowing which fuse was open. He also wanted to know whether the fuse was on the "high" leg (on a four-wire delta system) or in one side of the Edison three-wire distribution system. Not being able to tell the difference between 120 and 180 volts on the first "feel," he wet his fingers and tried again! This time he identified the lines properly, then went ahead with the necessary work on the system.

While we do not want to go on record as condoning this type of measurement, we have found that one can't teach an old dog new tricks, and have been forced to admit that our friend of forty or fifty years experience in the electrical game is certainly an interesting variation of the voltmeter. He is a self-contained two-range instrument of low sensitivity with dry fingers and high sensitivity with wet fingers; his accuracy is within plus or minus about 20% between 50 and 400 volts, he is equally useful on a.c. or d.c., gives the answers visually, and has the added advantage of being self-propelled. We have almost decided to ask for his transfer to the instrumentation department so we can start breaking him in on temperature measurements.

There are still (and always will be) many things which are impossible to do or to determine by instruments — although the foregoing case certainly isn't one of them. In fact, we have the greatest admiration for the men who deliberately starve themselves to exhaustion, expose themselves to the bites of disease-transmitting mosquitos, submit themselves to pressure, vacuum and acceleration extremes, or otherwise knowingly and willingly endanger their lives in the interests of the advancement of science. Much that we know today has been learned at the expense of the lives of human "guinea pigs."

However, where such drastic measures have now been made unnecessary by the development of instruments which will do such jobs safely and more accurately, such practices should be discouraged. No longer is it necessary, for instance, for a test pilot to endanger his life by flying a new and untried plane until it has been flown by radio-robot control, and flight data has been recorded or transmitted to a crew of observers ensconced safely in a control room on solid ground. No longer is it necessary, friend electrician, to try to distinguish between two different voltages or identify a blown fuse by inserting yourself in the circuit when we have trustworthy instruments at your disposal.

The same applies to the more standardized and commonplace problems of measurement and control. Instruments are now available which will out-perform manual control in more ways than we have space to mention, and measure almost anything with an accuracy undreamed of not so many years ago. It behooves us to take the fullest advantage of them.

So far, no one has developed an instrument or machine to do our thinking, loving, eating, sleeping, and bearing children for us, so let us try to get more enjoyment from these phases of living by letting the instruments of today and tomorrow relieve us of as many of our problems as they can.

—RRP

Editor's Notes

1. 26 STARS NOW IN OUR BANNER

As reported in the February issue of the *Journal*, three new Sections have been admitted, bringing our total number of Sections as of February 15 to twenty-six. We take this opportunity to welcome the three Sections admitted recently, namely; the Eastern New York Section, the Central Indiana Section, and the Aruba Section. We hope to have the names of the Secretary, Delegate and *Journal* Correspondent of each of these Sections in time to publish them in the next issue.

2. THREE MORE CHARTER APPLICATIONS!

According to Dick Rimbach, National Executive Secretary, the National Office has received requests for charters from three more groups:

Cincinnati requesting charter in the name of the Cincinnati Section. Secretary pro-tem, R. F. Romell, Vulcan Copper Co.

Lousville requesting charter in the name of the Louisville Section. Secretary pro-tem, S. W. Hawkinson, Brown Instrument Company.

South Bend requesting charter in the name of the South Bend Section. Secretary pro-tem, G. E. Gilliam, Brown Instrument Company.

These three groups will add another hundred or so Ohio, Kentucky and Indiana instrument men to our rolls. Such growth is certainly an encouraging sign of health, and it is our hope that those who, less than two years ago, held pessimistic views regarding the growth and expansion of the Instrument Society of America have had their doubts dispelled by now. We understand that several other groups, some of long standing, some recently organized, will soon be petitioning for charters. From where we sit, it looks like Dick Rimbach's prediction of 40 Sections by September will come close to being realized.

3. THE NEEDLE POINTS TO:

Detroit and New Jersey—for general excellence of their reports.

Chicago—for getting a lot said in the minimum number of words.

Practically every Section submitting reports this time deserves honorable mention. The quality of all reports, in general, is going up. The only thing we have to worry about now is that some of them are getting a little too long-winded, and we are forced to use our editorial pencil more and more.

With the rapidly increasing number of Sections, the editing of so much Section News material will eventually become our biggest job in getting the *Journal* ready each month. Hence, the following request is made of all *Journal* Correspondents:

Since it is not the length of the article that counts, but rather the quality, please try to make your reports brief but meaty. The abstract of a speaker's talk, for instance, should be handled in a very few sentences since, in most cases, Program Chairmen of other Sections will be the most interested in that portion of the report, especially if they are looking for prospective speakers for their Sections.

The use of a lot of names is usually not of general interest except to the members of your own Section. That is why we usually delete references to new members unless, in our opinion, such information is of particular interest. We are not asking you to leave all names out, however. This is a matter for your judgment.

We would like to request especially that reports be submitted in duplicate, typed double-spaced, and held to between one and two pages if possible.

If the above suggestions are followed, it will ease the burden considerably on your Editor, who is trying to handle a full time job and have a little time with his family, in addition to playing Editor for a considerable number of hours each week now. Your cooperation in preparing usable, newsy and interesting Section News articles each month, and getting them in on time, will be greatly appreciated by yours truly. —R. R. PROCTOR

Instrument Developments in Britain*

By H. B. CRONSHAW

PART THREE

At the H. H. Wills Physical Laboratory, University of Bristol, the development of an improved form of Schmidt camera by E. A. Linfoot and his assistant, Dorothy G. Hawkins, merits special attention as it has applications in television and mass radiography, where the very faint picture on the fluorescent screen has to be photographed with a reasonably short exposure.

Just a word about the original Schmidt camera—sixteen years ago, Bernhard Schmidt devised an optical system consisting of a spherical mirror and an aspheric plate which removed the heavy off-axis coma of parabaloidal mirrors restricting the use of astronomical telescopes to very small fields, and this discovery resulted in the classic Schmidt camera. The remarkable success of this camera soon attracted the attention of lens-designers, and certain improvements followed, but it was not until 1944 that Maksutov conceived the idea of replacing the plate in the Schmidt system by a thin meniscus lens.

Now Linfoot has succeeded in effecting a further improvement by replacing the plate with a combination of an aspheric plate and a meniscus lens concentric with the mirror surface. The performance of this meniscus-Schmidt system at a nominal aperture of *f*/1.2 is much superior to either of the other two systems. The color-error introduced by the meniscus is compensated by making the plate in the form of a cementable doublet with a spherical interface. An account of this work was published in the *Monthly Notices of the Royal Astronomical Society*, Vol. 105, 1945, page 334, under the title of "An Improved Type of Schmidt Camera."

Engineers' Measuring Instruments

The continual rise in the standards of accuracy demanded throughout the toolmaking and engineering industries, coupled with the great increase in mass production under the stimulus of the two wars, has led to great improvements in gages and measuring instruments required for the control of size in engineering production and inspection, and there has, in consequence, been a remarkably rapid expansion of this section of the instrument industry.

British research in this field has been almost entirely carried out by the Metrology Division of the National Physical Laboratory. In fact, most of the high precision gages and measuring instruments now being manufactured are based on designs developed at the N.P.L. Two of the N.P.L.'s publications, "Notes on Screw Gages," and "Notes on Gage Making and Measuring," are keystones in dimensional and geometrical instrumentation. All this work has provided a sound basis for the specifications drawn up by the British Standards Institution. An excellent account of modern methods of measurement and measuring instruments used in engineering production and inspection was given in May at the Exhibition of British Instruments, held in Sweden, by F. H. Rolt, Superintendent of the Metrology Division of the N.P.L.

Such, however, has been the growth of this section of engineering that additional facilities for research are needed, and with this in view the Gage and Toolmakers' Association, in conjunction with related bodies, has just founded a separate research organization under the title of "The Production Engineering Research Association of Great Britain."

The Gage and Toolmakers' Association was formed in 1942, with a membership of about 200 firms manufacturing machine tools and gages and measuring instruments. In January, 1946, the first national exhibition to be held after the war was a Gage and Toolmakers' Exhibition organized by the Association. Over 80 firms exhibited and half of them showed gages and measuring instruments. It was evident that tremendous expansion in output, and equally remarkable improvements in design and precision, had taken place during the years of the war. Some of the exhibitors were newcomers in the field of instrumentation. Improvements in design and general construction were particularly noticeable in the case of Measuring Machines, Dividing Heads, Optical Projectors, Comparators, Dial Gages, Caliper Gages, and Thickness Gages.

It is interesting also to note that the formation of a co-operative selling organization to promote export sales, under the title of "The British Engineers' Small Tools and Equipment Co., Ltd. (BESTEC) is a sign of the active preparations which are on foot for a drive in exports.

Surface Finish

The term "surface finish" refers to the degree of smoothness (or roughness) of a finished surface as determined by the height, wavelength and waveform of the surface irregularities. The importance of the subject lies in the fact that performance is largely dependent on the characteristics of the surface finish. Each intended function has its optimum surface qualities. In other words, each kind of job demands a right kind of finish for the best performance, and this is not necessarily the smoothest.

The measurement of surface finish and the interpretation of the data in relation to function and performance is a branch of engineering instrumentation which has grown rapidly during the war. The great interest that now exists in the subject was clearly demonstrated at a Conference held in London in March, 1945, at the Institution of Mechanical Engineers.

It is instructive to note some of the outstanding points made at the 194 Conference. In the first place the Conference was unable to find satisfactory answers to the fundamental questions "What exactly are we trying to measure and how shall we define it?" From this it obviously follows that one of the first things to be done in reducing confusion of thought is to clear up and rationalize surface terminology, and it would be a great advantage if this could be done on an international basis. In fact, as one might have expected, the meeting brought to light considerable diversity of views on fundamental matters and revealed something of the number and complexity of the problems awaiting solution. It is not surprising, therefore, that there was a general feeling of the need for more research. It was also felt that this research should be on a co-operative basis so that industrial laboratories, universities, etc. can be linked up by a central body. Such a body would stimulate, correlate and generally guide and assist the work.

Engineers are still a long way from knowing what types of finish are required for given purposes. What are the effects of surface finish on machine performance? What finish is necessary for good performance in given mechanisms? Until more is known about these relations it is not possible to decide what characteristics of a surface should be measured, nor how best to measure them. There is very little information that will enable designers to estimate the results to be expected from various types and degrees of surface finish either as regards life or performance.

On the question of standardization it was felt that this must be preceded by the rational specification of surface finish, and this appears to require further development of practical methods of measurement. It would be premature to develop a standard if it involved the complication of an auxiliary specification for surface-measuring instruments. Standardization of complete instruments, and of their essential components (e.g. styles and skid) should be deferred until greater and more general experience in their use has been gained.

When a standard specification becomes possible, it should cover drawing symbols for surface finish, but should be cautious in stipulating methods of production. There is a good deal of opinion favorable to separate but

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Pa., Sept. 16-20, 1946.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

ted indices of dimensional accuracy
d surface finish.

There is a need for cheap and robust
struments capable of rapid and re-
able workshop use in relatively un-
illed hands, preferably employing
veral existing principles of surface
praisement in combination. It was
served that standards of surface
ughness were in every-day use in
erica for controlling the quality of
ish in the workshops. C. Timms, of
N.P.L., suggested that this simple
thod of direct comparison could
th advantage be carried a stage
rther by using two standards for
h grade of finish, one corresponding
the upper limit of roughness and the
er to the lower limit. Workshop re-
ence standards could be readily
ibrated by any of the existing sur-
e measuring instruments.

Boundary Conditions

The "physical" condition at or below
surface has a marked effect on its
tion and wearing characteristics,
d on its interaction with lubricants.
is condition can be influenced by
erations prior to the final ones, i.e.,
its previous history. In London,
of. G. I. Finch is making a study of
ding surfaces in relation to the
eakdown of boundary lubrication,
h formation of an amorphous, glassy
wed layer, and of graphite and oxide
ers. Electron diffraction has thrown
ch light on these phenomena.

Sliding surfaces are meant to be
t apart by the lubricant and if
s were achieved in practice, wear
part from corrosion) would hardly
ur. Modern engineering conditions
e focused attention on boundary
nditions of lubrication, especially on
ir breakdown and its consequences.
e root cause of breakdown is surface
xture, which is responsible for an
even load distribution and for local
kening of the boundary oil film at
sicely those spots where the load-
tends to be excessive.

When breakdown occurs, the sliding
rfaces are subjected to a mutual
ishing or burnishing process which
s not consist of a mere wearing
way of high spots. It is now known
t the "run-in" metallic surface is an
orphous glass-like layer caused to
into the valleys by high local fric-
al temperatures and pressures ex-
ed at high spots. Thus polishing not
ly results in textural changes but
in profound and important changes
structure.

Not all the flowed metal adheres to
surface; some is lost and thus con-
utes to wear. This loss seems to be
gely connected with the distance of
before reaching a lodgment. Thus,
the scratches lie at right-angles to
sliding motion, wear is at a mini-
n; otherwise the flowed material
travel far enough to solidify and
before it has a chance to adhere to
substrate, and thus remains in the
to be carried away as detritus.

Corrosion

The study of corrosion affords another instance of a concerted attack on problems having a very wide spread. Until recently this field was largely confined to chemists and metallurgists, but there is now a growing tendency for physicists to join forces. Last year the Institute of Physics arranged a symposium on Corrosion, and papers were given by investigators from Research Associations concerned with metals, coal, telecommunications, and chemical processing, and by Dr. J. C. Hudson, Investigator to the Corrosion Committee of the Iron & Steel Institute. In this work the latter is associated with the Admiralty, as well as with shipping and civil engineering interests.

Many corrosion factors are purely physical. Broadly, they comprise (1) those of an environmental nature, arising from atmospheric immersion, and buried conditions, and (2) those associated with the metal itself, such as surface conditions, inclusions, internal stresses, movement of electrolyte, and concentration of dissolved substances, particularly oxygen. Factors of the second group lead to potential differences, which in turn give rise to formation of films of ions, gases, and solids determining the corrosion behavior of the metal. Electrode potential measurements provide a means of studying the behavior of these films, including their rate of formation, or breakdown or re-formation if damaged, i.e., the measure of protection they afford.

At the British Non-Ferrous Metals Research Association, P. T. Gilbert has devised an instrument for measuring and recording electro-chemical quantities in corrosive action, by means of which the potentials and corrosion currents from four couples of corroding metals are simultaneously and continuously recorded.

Internal Texture

The examination of internal texture has received no less attention than that of surface texture. Well established methods, such as the powder, fluorescent, supersonic, radio-frequency and radio-graphic methods have been extended, but it is doubtful if one can instance any development which is unknown to you here.

The same applies to strain gages, vibrographs, deflectographs, stress recorders, torsional damping recorders, and dynamic balancers. Investigations on strain gages were actively pursued during the war by the National Physical Laboratory and by several other laboratories. Recently the Steel Research Association, after making a detailed survey of all existing types of strain gages suitable for rolling mills, has developed a new type that is claimed to be a distinct improvement on all previous instruments. I have some information on this work, but a full account will shortly be published. I might also add that the general field of strain gages and strain viewers was covered in considerable detail only two months ago at a conference arranged in Manchester by the Institute of Physics. No doubt some or all of the papers will appear in the Journal of Scientific Instruments, and it is possible they will also be published separately.

For a good review of non-destructive testing, I would recommend a paper by Polgreen and Tomlin, which was presented at a meeting of the Society of Instrument Technology, held in April, 1945. Special attention is given to radio-frequency crack detectors and to the magnetic sorting bridge. The former depends for its operation on the fact that radio-frequency currents travel on the surface of materials and that any crack in the surface will interfere with the flow of current. The material being tested is passed through a coil which forms part of a tuned circuit, and the alteration of the frequency of the current due to the presence of cracks operates frequency-selective relays, causing a lamp to light, while the depth is indicated on the dial of the instrument.

Spectrographic Analysis

Co-operative research was successfully applied to emission spectrographic analysis during the war. This arose out of a survey made by the British Standards Institution in 1941, which showed that methods then in use for zinc alloys were not sufficiently precise to form the basis for a standard specification. In order to prepare recommended methods a group was formed representing the Admiralty, Armaments, Supply, and Chemical Departments of the Government, along with the National Physical Laboratory, the Non-Ferrous Metals Research Association, a firm of instrument manufacturers, and several smelting companies in Britain, Canada and Australia. Experimental work carried out in the laboratories of these concerns was planned and examined by the group, and the results published in a handbook issued in 1945 by the Ministry of Supply. A paper by Nickelson and Stubbs described an accurate oxide ore method and records some important investigations into the factors influencing sensitivity, reproducibility, and plate characteristics.

Another record of co-operative research in the same field is contained in a handbook of "Collected Papers on Metallurgical Analysis," issued by the British Non-Ferrous Metals Research Association. These papers have been selected from the research reports submitted to the Associations's Spectrographic Panels, some of them by members of the Association's staff, others by works' laboratories. They constitute a very important contribution to spectrographic technique. They deal with the examination of aluminum and aluminum alloys, lead and lead alloys, zinc alloys, copper alloys, and platinum. Actually they cover a much wider field and contain much useful information

on general matters of technique, including two papers on the processing and calibration of plates.

I might also mention that at the Association's laboratories, A. Walsh has devised a new general-purpose source unit for spectrographic analysis of metals and alloys. This is a simple inexpensive unit, and besides providing a simple condensed spark and a low-voltage d.c. arc, also provides a wide range of intermediate conditions. It employs a triggered low-voltage discharge which can be arranged to give high sensitivity together with a higher accuracy than is possible with a d.c. arc, or to give a high degree of reproducibility. Experiments with aluminum, zinc and lead alloys indicate that higher accuracy is obtainable than with the simple condensed spark. The circuit consists of a charging current, a discharge circuit, and a triggering circuit. The type of analytical work determines the type of excitation selected. For high sensitivity an arc-like discharge would be used (i.e., high capacity and high resistance) and the indications are that the accuracy and sensitivity obtainable equal those for high-voltage a.c. arc work. As for reproducibility, preliminary experiments suggest that high reproducibility is obtainable under selected conditions which primarily include low capacities.

The latest addition to the common stock of knowledge concerning spectrographic analysis was made only two months ago, in July, 1946, when a conference was held in London by the Institute of Physics. Modern equipment was reviewed by Nickelson and Garton, including an outline of photoelectric techniques used in the United States. A. Walsh explained that the function of the light source in spectrographic analysis is the vaporization and excitation of the material under test, and for accurate analysis it is essential that these proceed in a controlled and reproducible manner. He referred to his new device for combining the sensitivity of the d.c. arc with the accuracy of the condensed spark. From a consideration of the mode of operation of these light sources, it is possible to draw conclusions as to what characteristics can be expected from a given type of discharge, but the processes that occur are by no means completely understood. One interesting recent finding is the fact that the method of initiating or "triggering" the discharge affects the subsequent discharge to a marked extent. Control of electrical conditions is only the first step in obtaining reproducible spectra; it now appears that the selection of a suitable type of discharge is equally important.

Sources of error was the subject discussed by H. T. Shirley, and his conclusions were based on a statistical examination of a large number of readings from repetition spectrograms obtained from a single sample of 2.75% nickel-chromium-molybdenum steel. The main sources of error were found to be:

(a) Variability arising from sample response under excitation,

(b) Local variations in photographic plate over all areas,

(c) Reading errors.

Shirley found considerable differences between various types of plate, but the effect of development procedure was small. Excitation response was found to be very variable, and in many cases contributed a high proportion of the total error. This suggests the need for further work to gain stricter control. Some improvement was obtained from a 15-second pre-spark.

X-RAY AND INFRA-RED SPECTROSCOPY

Judged by the large attendance at a conference held in London by the Institute of Physics in July of the present year (1946), there is intense interest in the subject of x-ray spectroscopy. This conference revealed something of the large amount of fundamental work, such as that relating to the molecular structure of proteins, which is being carried out at the Universities of Cambridge, Leeds and elsewhere, but it gave no indication of the status of technological applications of x-ray spectroscopy. There is, however, little doubt that x-ray spectroscopy finds considerable use in the laboratories of the larger industrial concerns, but there is equally little doubt that the subject is badly in need of active promotion by somebody independent of private laboratories. At a previous conference the relative merits of the powder-camera, refractive index, and goniometer methods of identifying crystals were debated.

Curiously enough, the technological advance of infra-red spectroscopy has been more rapid; at least it has been more obvious. At this year's conference the need for increased speed and convenience in operation was stressed by Lothian and Thompson. Thompson possesses a remarkable grasp of infra-red work from both academic and industrial standpoints. His department at Oxford University has a very high degree of skill in this work. The only trouble is that it ought to be about ten times its present size to meet present-day requirements.

In this connection it is interesting to note that Sir Howard Grubb, Parson & Company of Newcastle-on-Tyne, will shortly start manufacturing an infra-red gas analyzer.

POLAROGRAPHIC ANALYSIS

A report by Nickelson and Randles of co-operative research carried out by the British Standards Institution Panel of the Non-Ferrous Industry Committee during the war on polarographic analysis contains valuable data, and is issued by the Ministry of Supply. Briefly, accurate methods have been devised for:

(1) Determining Fe, Cu, Pb and Cd in nitric acid solutions containing sodium citrate,

(2) Determining Cu Pb, Sn and Cd in hydrochloric acid solutions,

(3) A simple automatic method f removing Cu in HCl solutions. Rec mended methods are detailed and a vice given on the preparation of ca bration graphs. A comparison is m between results from spectrograp and polarographic methods. Agreeme was in most cases within 0.0001%.

RHEOLOGICAL TESTS

This branch of study, embracing t deformation and flow of matter, a the properties and conditions impl by terms such as stress, strain, pl ticity, elasticity and viscosity, and general the mechanical properties complex materials like clay, rubb plastics, paint, butter, cheese and cream, presents many difficult proble to physicists and also to technologi who are interested in the testing a quality specification of these material

The subject ranges over a very w field, but one aspect, namely, the m effective ways of relating stress, str and time, attracts particular attenti as a problem of fundamental imp tance from both analytical and tegrative standpoints.

In Britain the subject has be actively developed by Dr. G. W. Sc Blair at the National Institute for R search in Dairying, University of Rea ing, where, of course, interest is pri arily centered on the rheological stu of butter and cheese, especially t latter. Much progress has been ma in devising methods and instrumen for measuring the physical properti of curd and cheese during manufactu ing operations and of relating these the purely subjective tests applied the cheesemaker.

However, Scott Blair does not co fine himself to cheese. He ranges ov the entire field of rheology and has su ceeded in arousing considerable intere in the subject.

In April, this year, at a meeting the British Rheologists' Club, Dr. Bat Smith, of Cambridge University, di cussed rheological problems in meat r search. One is the nature of th change which muscle undergoes duri rigor mortis. This is due to a 5-to-1 fold increase in the modulus of el ticity of the muscle fibers in a long tudinal direction. Another problem the measurement of toughness for t purpose of evaluating quality and es mating its improvement due to cond tioning and other "tenderizing" pr cesses. Several instruments for measu ing toughness were described.

Rheology also enters into gelati manufacture, in the measurement elasticity and plasticity to determi grade and performance. Shear modul increases approximately as the squa of the concentration, up to 60 perce Plasticity is greatest with low je strength grades.

Piper and Scott at the Researc Association of British Rubber Man facturers have developed a new "shea ing-cone" plastimeter for investigati the plastic-flow relations of high viscous materials over a wide range

ss. The plastic flow of unvulcanized ber and other high polymers does in general obey Newton's law that rate of flow is proportional to the ied stress. The viscosities of these erials are a function of their rate hear. For a complete knowledge of plastic flow, it is necessary to de- ine the rate of flow at various sses, the effect of temperature, and re thixotropic or other time effects present, the effect of time of appli- on of stress. A plastimeter for this ose should thus be capable of suring the stress required to pro- several definite rates of plastic , and of maintaining the stress con- nt so that time effects can be studied. factory control, the rates of flow ld be of the same order as the rates untered in processing the material.

AUTOMATIC CONTROL SYSTEMS

ajor Behar tells us that 20 years in America, the word "instrumen- on" was an offense to professional and was something of a butt for d-natured chaff. I understand it was ely through his persistence that the d came eventually to be accepted respectable circles.

part from greater lag, much the e thing has happened in Britain. he few years before the war it was ming more and more evident that ruments must be regarded as an ral part of the plant itself rather as individual pieces of mechanism ched to this and that component of installation. It became more gen- lly recognized that instrumentation ld be designed into a process and merely stuck onto the plant. In- d of being the last consideration, etimes merely an afterthought, in- mentation should be one of the first iderations in plant design. I seem member reading somewhere in your rnal that the true function of the ess engineer is to visualize the t operation as an integrated pat- of operational conditions in a mic state of balance, with the in- mentation maintaining the balance inuously.

Nevertheless there are a few chemi- engineers here and there who are t entirely "sold" on instrumentation. ately, we were warned by a speaker a conference that measurement of w of the physical variables, even they do provide a sufficiently accurate e in establishing operating con- ions, is not always sufficient to give knowledge of the reacting substances. y operations require a chemical owledge of the reacting substances at y instant throughout the process. oubtless the instrument man will this as a sign that he has reached last ditch of the chemist, and will cribe more instrumentation. But habits of thought are threatened from another quarter, quite unexpectedly. This comes from military science, in the form of the gospel of servomechanisms, defined as a special type of control system which is completely automatic in operation and in which the movement of a heavily loaded output mechanism follows the control of an input mechanism without imposing any restraint. A servomechanism is regarded as "error-actuated," i.e., it is actuated by a function of the difference between the input and the output quantities, the purpose of which is to reproduce at a potentially higher level some input quantity that it is independent of the operation of the control system.

This conception mainly arises from a special aspect of automatic control, in the form of positional control, developed during the war. For example, an anti-tank gun is made to follow automatically and accurately the movements of a comparatively feeble controlling device (coupled to the sights of the controller), the exact alignment being brought about by an "amplification" of the existing misalignment.

An interesting example of a servomechanism was described by T. M. Berry in *Transactions American Institute of Electrical Engineers*, 1944, page 195. This is a polarized light system, consisting of a primary polarizer mounted on a primary shaft, transmitting light in two beams through two secondary polarizers on a secondary shaft, and set with their axes at right angles. Then the beams pass to two separate photo-tubes. There is thus a single position of the secondary shaft for which equal amounts of light enter both photo-tubes. A slight rotation of the primary shaft in either direction will unbalance this light. The unbalanced output is amplified and transmitted to a bridge circuit which brings the secondary shaft in phase with the primary.

Applied to temperature control, the servo-principle is interpreted as consisting of a system for amplifying the difference between the actual and the required temperature values, and employing the amplified difference to effect the adjustment.

At a conference held in London last year on automatic control, Prof. K. A. Hayes of the Military College of Science explained that while the military and industrial applications have a common basis in theory there are quantitative differences which have led to a somewhat different development of these two branches of automatic control. On the one hand, there is the contrast between the rapidly moving mechanical parts of a servo-system and the slow variations of a process variable. On the other hand, it is much more difficult to make a quantitative analysis of a process (such as the heat transfer in a liquid stream with poorly defined boundaries), than of a mechanism with the "lumped constants" of masses, springs, dashpots and electrical voltages or currents.

Thus it is not surprising to find that the mathematical analysis and systematic classification of automatic control systems has made its greatest strides in the field of servomechanisms, states Prof. Hayes. It is now proposed to extend this treatment to corresponding problems in the industrial field.

Last year a publication on "The Application of Control Systems in Industry" was issued by the Ministry of Supply's Technical Committee on servomechanisms. It was prepared by Dr. A. Porter, who is now at the National Physical Laboratory. The paper stresses the urgent need for the establishment of a central research group to study industrial control problems, and the belief is expressed that the principles used in the design of control systems for military equipment can be applied quite generally to a wide range of industrial control problems. It is acknowledged that although British scientists have contributed much to the theory and design of control systems, America is far ahead in applying this theory in industrial practices. Dr. Porter urges that a strong effort be made to coordinate the work of the few British control specialists and to increase their number as rapidly as possible.

I am pleased to say that these recommendations have had the desired effect, and that a department has been formed at the National Physical Laboratory designed to study the fundamental aspects of automatic control systems with special reference to industrial problems.

Forthcoming measures to add momentum are a convention on automatic control, which it is hoped to arrange as early as possible, and a paper by Dr. Porter on "Basic Principles of Automatic Control Systems" which is soon to be read at a meeting of the Institution of Mechanical Engineers.

CLEVELAND MEETING DATES CHANGED

The Spring Regional Meeting of the I.S.A., to be held at the Hotel Carter in Cleveland, and announced in these columns last month, has been changed from April 4th as previously announced to April 24th.

An excellent program is shaping up and this meeting should be well worth attending.

The dates for the Educational Committee meeting and the Board of Directors meeting have also been changed. The Educational Committee will now meet on April 23rd, and the Board of Directors will convene on April 25th. The Board of Directors Meeting will be preceded by a meeting of the Executive Committee.

Be sure to correct these dates on your calendar.

Plan Now To Attend • **1947 I. S. A. CONFERENCE AND EXHIBIT**
September 8-12, 1947 **Stevens Hotel, Chicago**

General News

I.S.A. to Participate in Chicago Production Show

At the forthcoming Chicago Production Show and Conference at the Stevens Hotel, March 17, 18 and 19, 1947, sponsored by the Chicago Technical Societies Council, three panel sessions which are expected to be of especial interest to attending production men are those arranged by the Chicago Section of the Instrument Society of America.

On Monday, March 17, at 2:00 p. m., the general subject of Automatic Controls will be discussed by two authorities in this field. The first speaker will be V. V. Tivy, Technical Engineer of the Foxboro Company, Foxboro, Mass., who will talk about "Air-Operated Controllers (including a discussion of the derivative functions)." The second speaker, whose name had not been secured at this writing, but who will be a representative of the Brown Instrument Company, will discuss "Pyrometers and Pyrometric Controls." The technical chairman in charge of this session will be Diamond S. Dickey of Murphy & Dickey Company, Chicago.

The second I.S.A. panel session will be presented at 10:00 a. m. on Tuesday, March 18, under the chairmanship of C. C. Hurst of Garden City Engineering Specialties Company, Chicago. The first speaker will be J. B. McMahon, Application Engineer, Republic Flow Meters Company. Mr. McMahon, who is also a National Vice-president of the I.S.A., will present "A Non-Mathematical Treatise on Flow Measurement." The second speaker on this panel will be O. M. Haseltine, President of Service Associates, Inc., Chicago, who will speak on "Servicing and Repairing Pyrometers and Controls."

Electronics is the general subject of the third session, to be presented at 2:00 p. m. on Tuesday, March 18. Louis E. Pepperberg of Zenith Radio Corporation will act as chairman. The first speaker, W. R. Mahaffey of Armour Research Foundation, will speak on "Application of Electronic Measuring Equipment to Production Problems." The second speaker is to be P. B. Korneke, General Electric Company, whose topic covers "Electronic Controls as Applied to Non-Electronic Industries."

These sessions have been arranged by a special committee of the Chicago Section under the chairmanship of J. H. Havens, of the Lonergan Company.

Report of Activities of 1947 Exhibit Committee

Just prior to the opening of the "Instrumentation for Tomorrow" Conference and Exhibit in Pittsburgh last September, the 1947 Exhibit Committee was organized for the purpose of selecting space for the Second Annual Conference destined to be held in Chicago.

The function of this committee includes the laying out of booths, determining the cost of exhibition space, inviting prospective exhibitors to attend the conference and display their products, and arranging for the execution of space contracts under the guidance of the National Executive and Conference Committees.

The Exhibit Committee acts also as liaison between the Executive Committee and the Space Allocation Committee, which assigns the exhibition space to the exhibitors.

The following men comprise the Exhibit Committee:

T. G. Robinson, The J. W. Murphy Company, Chairman; G. G. Gallagher, Universal Oil Products Company; I. H. Hunciker, Sanitary District of Chicago; J. N. Swarr, Corn Products Refining Company.

At a meeting of the National 1947 Conference Committee in Chicago on January 27, 1947, the "Exhibition Space Allocation Committee" was appointed and organized for the purpose of assigning booths to the exhibitors.

This committee, composed entirely of "instrument users," is as follows: Don J. Bergman, Universal Oil Products Company, Chairman; Earl C. Rieger, International Harvester Company; H. E. Ferguson, Peoples Gas, Light & Coke Company; R. R. Proctor, The Pure Oil Company; H. C. Frost, Corn Products Refining Company.

As this report goes to press, about 40% of the available space at the Stevens Hotel Exhibition Hall, where 168 booths have been laid out, has been assigned. Within the next two or three months it is planned to publish in the *Journal* the floor plan diagram of the exhibition space, together with the assignments which have been made at that time.

The Exhibit Committee has been acknowledging and signing up space contracts as rapidly as possible, and every effort is being made by both of the above committees to cooperate to the fullest extent with all exhibitors and prospective exhibitors in fulfilling their wishes.

Any suggestions or inquiries about exhibition space for the 1947 Exhibit will be given immediate attention.

—T. G. Robinson, *Chairman.*

News of Sections

CHARLESTON

On Monday evening, February 3, 1947, Willard N. Greer and J. F. Sneath of the Leeds & Northrup Company dropped into the "Magic Valley" to entertain and enlighten the assembled members and guests of the Charleston Section. Dr. Greer, of the L. & N. Extension Division, headed the slate, speaking on "Conductivity and pH Measurements." His slides and accompanying remarks soon made us realize that everyone has much to learn on this subject and that there is much room for improvement in methods and equipment in this field.

The second half of Dr. Greer's talk dealt with pH. This was more or less a chalk-talk showing why pH is a convenient method of expressing the hydrogen ion concentration —it is the logarithm of the reciprocal of the hydrogen ion concentration, with a pH value of 7 indicating a neutral solution.

Following Dr. Greer's talk, Mr. Sneath brought out a new L. & N. temperature instrument and described it in an interesting and enthusiastic manner. We are indeed proud of this member of the Charleston Section who is so well known and liked abouts.

On February 17th the members of Charleston Section made an inspection of the Institute, W. Va., Butadiene operated for the United States Gover by Carbide and Carbon Chemicals Cor tion. The party was divided into grou six or eight and a guide was assign each group to point out items of int

On February 18th many of our me visited the American Institute of Che Engineers, which group was conduct symposium by local authorities on chlorine-alkali industry. (We loyal bers of ISA would appreciate learni some new and good excuses to giv wives so we can get out for more of activities!)

We are pleased to announce that th plications for membership are fairly ing in," thanks to the activities of G Preston and his Membership Comm And while we're passing out bouquet are not overlooking our man Mitchel hope the *Journal* readers are appreci his cartoons. Many of them are bas real events but have no reference to sons living or dead (and anyway it them right!) Thanks also, Editor Pr for your own good work and wor advice. We hope this news is in line the cooperation due you. We'll see y Chicago in September.

[Ed. Note: Perhaps we should hav leted this last thought on grounds of esty, but its our first bouquet turned Section News reports, and we probabl frame it and keep it for evidence!]

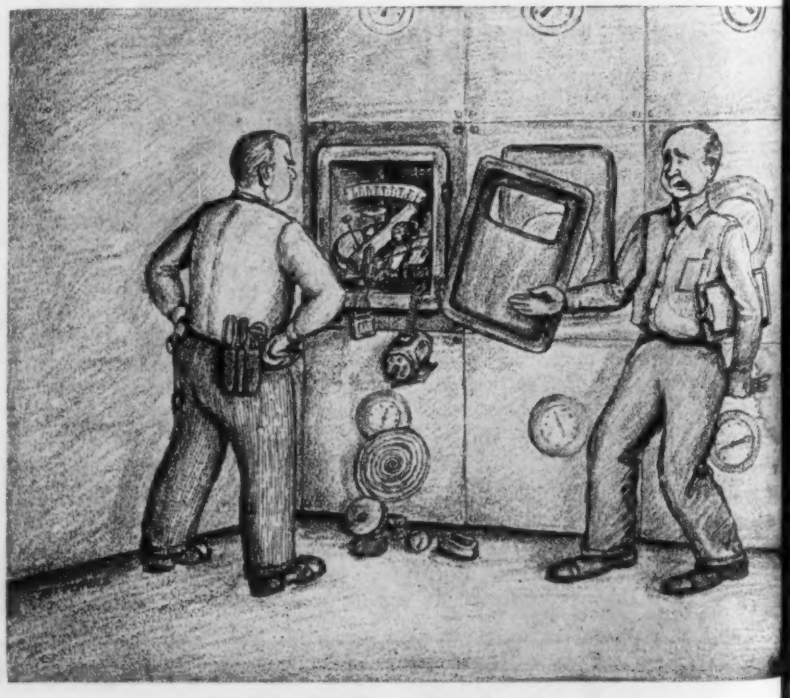
The next meeting of the Charleston tion will be held on Monday, March 3, Lyman Allen of American Viscose pany speaks on "Fractionating Co Control Considerations."

Monday, April 7, 1947—"Rotameters cent Improvements and Applications," Fischer & Porter Company.

—Carl Cavender, Sec

CHICAGO

The Chicago Section was introduce the subject of radioactivity at the Ja 6th meeting by Dr. Truman P. Kohm the University of Chicago. Dr. Kohm scribed the terms used in conjunction nuclear work and explained in some the application of radioactive materi



". . . but we didn't touch it, I tell you. It just fell apart on the midnight shift!"

form of tracers in the medical and bio- fields.

February 3rd meeting offered some- a little out of the ordinary to its ers and guests when five speakers ted their experiences in "Problems strumentation and Their Solutions." Offill, of Claud S. Gordon Company, as technical chairman and moder-

first speaker, Glen G. Gallagher of rsal Oil Products Company, discussed rol of Narrow Boiling Range Binary ms," with particular emphasis on a vapor pressure type of sensing ele- and pneumatic transmitter control developed by his department to give recise control demanded by the pro-

mer Suomi of the University of Chi- the second speaker, described a "Dew Recorder" developed at the University icago which is an improved version of ld-surface condensation type of hy- ter in which radio-frequency heating metallic mirror and a photo-cell de- circuit were two of its special fea-

rd on the program was Don J. Wange- the Pure Oil Research and Develop- Laboratories, who explained the "In- ent Requirements in Measuring the inability of Metals." His talk covered struments now in use or available for ring tool tip temperatures, tool forces ower requirement variations, for indi- and controlling the surface speed of ork, and for analyzing the surface of the work, and stressed the need w and different types of instruments e in such projects.

next speaker was V. H. Kraybill of Service Company of Northern Illi- whose subject was "Some Tests on the ning Mechanisms of Large Steam nes." His talk was a description of ickup-amplifier-oscilloscope-switching t set-up for determining the relation- between speeds, voltages, frequencies various valve motions and positions a sudden unloading of a turbine- generator.

h E. Ferguson, of Peoples Gas Light e Company, was fifth on the program a treatise on "Metering and Flow Con- Problems in the Gas Industry." His overed the use of pitot tubes and low ential pressure recorders at strategic in the mains of a large gas distri- system, and the improvements which effected as a result of this survey.

m the ensuing lively discussion and vorable comments received after the g, it was evident that the program ell received. Among the guests at this g (and who took part in the discus- was B. Dunglinson, Managing Direc- Electroflow Meters Company, of Lon- England.

March meeting, to be held on Mon- he 3d, will feature A. Kyle, of the S. Gordon Company, Chicago, who speak on "Instrument Maintenance ms."

Monday, April 7, the meeting will with dinner at the Georgian Hotel in ton (6:30 p.m.) where Dean Ovid W. ch of the Northwestern Technological ute will speak briefly on the activities acilities of this rapidly growing en- ing school. Following this, the group e turned over to Professor Richard W. of the Electrical Engineering De- ent, who will conduct a tour of the ological Center on Northwestern's ton Campus. Approximately ten de- ents or laboratories, each featuring a nt type of instrumentation, will be and described.

—J. C. VAALER, *Corr.*

CUMBERLAND

ty members and guests gathered for January 28th dinner and technical ing of the Cumberland Section, held at Queen City Hotel.

The speaker of the evening was Arthur Hermann, mechanical engineer in the Application Engineering Department of the Taylor Instrument Companies, Rochester, N. Y. Mr. Hermann gave a very interesting blackboard talk on "Time Cycle Control in the Process Industry," illustrating his talk with slides. Before closing he also showed some slides on Contour Time Control.

Among the guests at the meeting were Frank C. Fuzzard, Pittsburgh Sales Representative of Taylor Instrument Companies, and Mr. Huffman of the C. J. Tagliabue Division of Portable Products Corporation.

The next meeting is scheduled for February 25th.

—H. E. BISHOP, *Corr.*

DETROIT

T. A. Cohen, president of Taco-West Corporation, highlighted the January 27th meeting with a clear and vigorous discussion of the newer electronic pyrometry systems. Over 80 members and guests

Detroit Section officials caught in a moment of informal discussion following Mr. Cohen's talk on January 27. Left to right: T. A. Cohen, speaker; H. H. Barnum, Detroit Section Delegate and National Vice-President; Victor G. Raviolo, Section Secretary; James Gambrill, Section President.

crowded our new meeting room in the beautiful Horace H. Rackham Memorial Building.

Beginning with a resume of the minute forces available from thermo-sensitive elements, Dr. Cohen diagrammed in his "chalk-talk" most of the circuits, past and present, that have been used for the purpose of amplifying thermocouple voltages to levels suitable for the operation of reliable meters and control relays. He covered the newer electronic pyrometer circuits in considerable detail, pointing out the drawbacks and advantages of each design. Particularly noticeable was the complete absence of any type of sales message or attempt to influence the audience for or against any particular type or make of instrument.

Mr. Cohen's lecture was particularly well received, and was a fitting event for the "housewarming" meeting in our new location.

The Industrial Instrument Supply Company, providing the equipment display for this month's meeting, was represented by Charles Sherwin, local representative, and Frank Davis, president of the Davis Emergency Equipment Company, Newark, New Jersey, who personally invited inquiries about the safety and emergency alarm systems on exhibit.

The February 24th meeting will feature two speakers—F. G. Tatnall, Baldwin Locomotive Works, who will discuss "The Tate-Emery Cell and Indicator for Precision Force Measurements," and O. Heise, Heise Bourdon Tube Laboratories, who will talk about "Precision Bourdon Tube Gages." The S. Sterling Company of Detroit will exhibit at this meeting the new "DuMont Type 427-A Projection Oscillograph."

The March 24th meeting will also bring to us two speakers, F. R. Brydges, General Foods Corporation, will speak on "Unusual Control Problems," and P. Skeels, General Motors Proving Grounds, will discuss "An Electronic Counter."

—SIEGMUND KULKA, *Corr.*

EASTERN NEW YORK

[This group, formed as the Eastern New York Instrument Society in January, 1947, has recently acquired Section status by action of the National Executive Committee. The regular meeting date for this Section has been set for the first Tuesday in each month. —Ed.]

The first meeting of the Eastern New York Instrument Society was held on January 7th at Siena College in Loudonville, New York. Approximately 40 members were in attendance in spite of the icy conditions of the roads, and the attraction was a discussion by H. P. Kuehni on the subject of "Electric Gages." Mr. Kuehni is with the General Engineering Laboratory of the General Electric Company in Schenectady.

His discussion included an outline of the basic principles employed in electric gages, and he described the various means for converting displacement into electrical energy. He then explained how these basic principles were incorporated into finished instruments for making measurements, such as comparators, strain gages, and film thickness measuring instruments.

The regular meeting on February 4th, also at Siena College in Loudonville, will long linger in the memories of those able to attend (what is now known as) the "Polar Expedition of February 4th." Extremely stormy conditions and a heavy snow-fall prevented all but a score or so from attending.

Major M. F. Behar, Editor of *Instruments* magazine, was the speaker of the evening, his very interesting talk covering "Some Forgotten Fundamentals of Instrumentation." He reviewed the history of instrumentation, particularly the origin of the term, and the classification of measurement and control methods in which lie the foundations of the science.

The next meeting will be held on March 4, 1947.

The present slate of officers of this Section is as follows: President, N. Gildersleeve, General Electric Company; Vice-president, R. N. Clarke, Behr-Manning Corporation; Secretary, W. J. Claffie, Winthrop Chemical Company; Treasurer, J. M. Maitland, The Bristol Company; Membership Committee Chairman, T. Carse, Shiefer Electric Company; Program Committee Chairman, J. P. Smith, General Electric Company; Publicity Chairman and *Journal* Correspondent, H. R. Larsen, W. & L. E. Gurley, Troy; Educational Chairman, J. H. Brandeau, Behr-Manning Corporation; Financial Committee Chairman, Vice-president R. N. Clarke.

—H. R. LARSEN, *Corr.*

KANSAS CITY

At the regular meeting of this Section on January 28, Vice-president Oliver L. Boutros opened the meeting with the inauguration of a "Visitor Contest." Fifteen visitors were present, one of them being V. P. Newman, Plant Maintenance Foreman, Southwestern Bell Telephone Company, who was elected to membership before the meeting adjourned.

Ansel W. Stubbs, one of our members, gave a fifteen minute talk on "Coating of Optics," following which the "Quiz Kids" answered several questions concerning this subject.

The main speaker of the evening, Captain E. I. Hockaday of the Missouri State Highway Patrol, was then presented to tell us how scientific instruments are used in crime detection and solution. He cited specific crimes which had been recently publicized in the newspapers and told how each "case" was broken as a direct result of the use of a particular instrument belonging to

the Patrol Laboratory. These Patrol Laboratory Instruments were well described as a part of his talk.

Captain Hockaday proved to be a very interesting speaker, willing and able to answer the questions that were put to him upon completion of his talk.

Our regular meeting scheduled for February 25 will feature a basic lecture on some aircraft measuring instrument by a member of the Engineering Department of T.W.A., the "Quiz Kids," and the main speaker of the evening, W. A. Reichow, Manager of the local office of Minneapolis-Honeywell Regulator Company. Mr. Reichow's talk, to be accompanied by motion picture films, is on "The M-H Automatic Pilot."

—R. L. LEWIS, *Sec'y-Treas.*

NEW JERSEY

At the February 4th meeting of the New Jersey Section, a program on instrument education was presented under the chairmanship of John Kelly of Calco Chemical Company. After a brief talk by Les Williams, chairman of the Membership Committee, Sid Baran of R.C.A., acting in Mr. Close's absence, introduced the members of the panel for the discussion. The panel included Martin J. Ladden, Brown Instrument Co., Paul S. Creager of Rutgers University, and F. S. Rich of the Arthur G. McKee Co.

Professor Creager spoke first and briefly outlined the problems involved in setting up college courses on instrumentation. He brought out his suggestions as to how and at what level such courses could be started in our universities. Mr. Ladden spoke next and explained in as sufficient detail as time would allow, how he, as Supervisor of Brown Instrument's training school, presents their courses on this subject. He mentioned the limitations of this type of training, particularly that of time and available space. Mr. Rich spoke last and the keen interest in the discussion up to this point did not leave him much time. He did, however, bring out several interesting points on "on-the-job" training of instrument men and had available for examination the manual on the subject which was used at Oak Ridge. He also made some interesting comments on the success that Largo Oil & Transport Co. have had at Aruba in developing instrument mechanics of natives with no formal schooling. Several members and guests asked questions and made constructive comments on the material presented by the speakers.

A sure sign of a successful program is the necessity of stopping discussion so that the meeting could be adjourned at a reasonable hour. For this, our first program dealing with instrument education, we give a vote of thanks to John Kelly for conceiving the idea and organizing the program in such a fine manner.

There has been much discussion in Executive Committee sessions for some time endeavoring to find a way to interest instrument people in this section other than the process control group to take an active part in ISA activities. The program for the March meeting is the outcome of this and Sid Baran, our Program Chairman, has arranged a program which we hope will attract a large number of electrical instrument people. Arthur Liebscher of R.C.A. at Camden, N. J., will speak on "Application Technique in the Use of the Cathode-Ray Oscilloscope." It is hoped that sufficient interest can be developed to enable this Section to sponsor separate monthly meetings presenting subjects of special interest in the field of electrical instruments.

The subject for the April meeting will be a revival of the open forum on instrumentation which has attracted much interest in the past. Feeling that one of the basic purposes of the Society is the exchange of information between members, this program gives everyone a chance to bring their problems along and have them brought up for discussion and solution.

For the May meeting, we are pleased to present Bruce Irwin of Hammel-Dahl, who will talk on the "Selection of Control Valves for General Application."

Our June meeting, as previously announced, will be an inspection trip through parts of the Calco Chemical Plant at Bound Brook, N. J. We understand that a swell evening's entertainment is being planned and hope that all who can possibly do so will attend.

—GEORGE R. FEELEY, *Corr.*

NEW YORK

On January 27th, after a delicious supper at the Men's Faculty Club, Columbia University, the annual business meeting of the New York Section was opened by President Kayan at 8:00 p.m. Fifty members and guests were present. The reading of the minutes of the last meeting, including the nominations for officers, was followed by the Treasurer's annual report and its acceptance. Membership, Employment and Program Committee chairmen, and the Vice-president for the Executive Committee, gave their reports. The election of officers was accomplished on one ballot, as only one slate had been nominated.

Executive Committee of the New Jersey Section in session. Around the table left to right are: Herb Close, National Lead Co.; Les Williams, Foxboro; Walt Maurer, Taylor Instrument; Bill Ludi, Standard Oil Development; George Feeley, Trinity Equipment; Harry Moore, Standard Oil Development; John Kelly, Calco Chemical; Sid Baran, R. C. A.; and Bill Archibald, Energy Control. Dick Roberts, of Brown Instrument Co., past president and a member of the committee, is responsible for the picture.

The following officers and Executive Committee members were elected: President, H. L. Hildenbrand, Esterline-Angus Company; Vice-president, Ralph R. Batcher, Electronic Industries; Treasurer, Edward B. Schofield, Sperry Gyroscope Company; Secretary, Charles D. Corey, Danco Instruments. Executive Committee: Norman J. Cherry, The Bristol Company; Charles E. Haggerty, N.Y.C. Dept. of Public Works; E. R. Manning, Weston Electrical Instrument Corp.; O. B. Wilson, Brown Instrument Company; Saul B. Young, Cambridge Instrument Company.

Mr. Hildenbrand, the incoming President, acknowledged Mr. Corbett's many years of service as Treasurer. A fine wallet was presented to Professor Kayan, the retiring President, as a gift from the Section.

H. C. Roters, Director of Research, Fairchild Camera and Instrument Corporation, the speaker for the evening, was then introduced by President Hildenbrand. His lecture on "Construction and Characteristics of Hysteresis Motors," started with an explanation of what these motors were and how they operated. Power calculations were developed, hysteresis curves of several magnetic steels were explained, and characteristic operational curves were shown for different sizes of motors.

A lively discussion period followed, during which time several of the motors were shown. The meeting adjourned at 10:30 p.m.

—CHARLES D. COREY, *Sec'y.*

NORTHERN INDIANA

The regular meeting of the Northern I diana Section was held at the Lake H in Gary on Wednesday, February 19. A proximately 35 members and guests he J. B. McMahon, Application Engineer Republic Flow Meters Company, and tional Vice-president of the I.S.A., pres a very fine talk on "The Principles of Fl Metering."

Due to a last minute failure of the al projector, Mr. McMahon was unable to the excellent slides he had prepared, the chalk-talk he substituted probably just as fine a job.

Our March 19th meeting has suffered change of program just as this announ ment goes to the *Journal* Editor, and speaker's name had not been secured this writing.

On Wednesday, April 16, it is planned have Phil T. Sprague, President of Hays Corporation, present a talk on Co bustion Controls.

Our May meeting, to be held on Wedn day, May 21st, will be a social evening members and their wives and guests.

—ED. WHITE, *Publ. Chm.*

OAK RIDGE

The regular February 4th meeting of Oak Ridge Section featured J. J. Grebe, rector of Physical Research Laboratories the Dow Chemical Company, Midla Michigan. Following a short business me ing at which a draft of the proposed cha es in the local constitution and by-laws read, Dr. Grebe spoke on the subject "Unusual Control Problems."

His talk centered around graphic re tionships of automatic control variab shown by slides, beginning with the re tionships of various variables encounte when analyzing a control problem. Am the slides shown were valve travel *vs.* ti process inventory *vs.* time, flow thro control valve, condition of inventory due control action and due to load chan and record of process under various cont actions.

The speaker discussed in detail a spec titration problem for which he and his a sociates had to design a controller with third-order control action, or "damp second derivative function, the like of wh was not available commercially.

Dr. Grebe definitely impressed every present with his ability to solve diffic control problems. He has long been an ponent of the theory that automatic c trol analysis is possible and should be proached from the standpoint of simply graphically showing the relationships of variables under actual conditions ver the relationship under ideal conditio then seeing what control mechanism bring about the needed action. His talk thoroughly enjoyed by everyone attend

The March 4th meeting will feature E. Emerich and J. E. Schock of Leed Northrup Company in a joint discussion "The Development of Industrial Record —Through the Speedomax G."

The April 1st meeting brings us J. Michaelson of the General Electric C pany, who will speak on "New Devel ments at the General Engineering and C sulting Laboratories."

—CHAS. W. COVEY, *Corr.*

PHILADELPHIA

Wednesday, February 19th, E. Wellf Mason, Patent Attorney with Brown strument Company, spoke on the subj "Patents, What They Are and How Get Them."

On Wednesday, March 19th, Clare Petty will conduct the Annual Quiz P gram.

—C. W. WOOD, *Sec'y.*

PITTSBURGH

The January meeting of the Pittsbu Section was held at the Carnegie Insti on January 27, 1947. Dinner was served the cafeteria, after which the members

ed to the lecture hall where, as a pre- to the meeting, a short motion pic- entitled "Tornado in a Box" was n. This film, produced by the Allis- mers Company, demonstrated the prin- of the new gas turbine.

H. Shafer, Pittsburgh Delegate, gave ef report of the meeting of the Na- l Board of Directors which was held w York City on December 4th. After ort business meeting, during which s of the new by-laws of the Pittsburgh n were distributed to the members pproval, the lectern was turned over to peaker of the evening.

e subject of "Pressure Gages" was ably discussed by A. E. LeVan, United s Gauge Division of American Ma- s and Metals, Sellersville, Pa. Illus- g his talk with lantern slides, Mr. n traced the development of the Bour- tube from the earliest forms to the rn designs. The effects of wall thick- cross-sectional shape and hardena- on the responses of the instrument analyzed. Many methods of quality ol in various stages of the processing explained.

e next meeting of the Pittsburgh Sec- will be held on February 24th at Car- Institute. The subject, "The Endless —the Application of Electrical Re- ng Instruments to the Solution of lems of Industry and Technology," will resented by R. J. Kryter, Esterline- s Company, Indianapolis, Ind.

March 24th, A. F. Benson of Ameri- Meter Company will discuss "Flow surement."

—A. G. YOUNG, *Corr.*

ST. LOUIS

(Received too late for the February issue)

e St. Louis Section held its regular De- er meeting on Monday, December 30 e York Hotel in St. Louis. This was a le Header" Members' Night program hich:

W. G. Lee of National Lead Company e on "Thermocouple Wells in Chemical lications," with special reference to a -encased thermocouple developed by his any for use in a batch process where uric acid in various degrees of concen- on is encountered.

Carl E. Werstler of Socony-Vacuum Company presented a talk on "Thermo- le Tubes and Wells in the Petroleum stry." His discussion centered about thick-walled, hardened, stainless steel piece wells necessary in certain appli- ns in a refinery.

Roy Finch of the Owens-Illinois Glass pany described the silica-sheathed ther- mocouple installation in a 2800° F. glass-melting furnace, and the trouble encountered in maintaining reasonable life of thermocouples at such temperatures.

Many questions followed each talk, and the 50 members and guests present thoroughly enjoyed the evening.

The St. Louis Section of the A.I.E.E. has invited I.S.A. members and friends to attend their meeting of February 19 at which Russell G. Meyerand, Senior Electrical Engineer of the Union Electric Company of Missouri will speak on "Telemetering of Electric Load Conditions."

The regular meeting of the St. Louis Section of the I.S.A. on February 24th will consist of a conducted inspection-of-instrumentation trip through the Venice No. 2 plant of the Union Electric Company.

The next meeting will be held on March 24th, the subject and speaker to be announced later.

The closing date for entries in the Papers Contest sponsored by this Section has been advanced to March 7, 1947.

—H. E. ZEFFREN, *Corr.*

SOUTHERN MICHIGAN

"Instruments of Flight" was the theme of the February 12th meeting of this Section at Chicken Charlie's in Kalamazoo. Forty-five members and guests enjoyed the program, which was divided into two parts.

E. C. Weaver of Western Michigan College, dean of fliers in this area and a flier in World War I, told of the vast difference in plane instruments between those days of "seat of the pants" flying and present day plane instrumentation.

"Sandy" Sanderson, Public Relations Officer for the Michigan C.A.A., who served in World War II and flew the Hump for 15 months, explained the two methods now used to bring a plane down to a landing in zero visibility, one with the pilot flying it in on a radio beam, and the other in which radar is used by a ground control station to spot the plane's position and talk the plane down by radio. Mr. Sanderson said that while most pilots prefer to fly their own ships in, the fact remains that the ground-control-approach method is much safer. Unhappy publicity rather than actual volume of air accidents was blamed by Sanderson for the tough times now being experienced by air travel companies. He stated that the accident rate per passenger-mile flown is far lower than the corresponding rate for either rail or auto travel.

There was a general discussion following the two talks. Applications for five new members were received. —KEN MEAD, *Corr.*

WASHINGTON

The 28th meeting of the Washington Section held Wednesday evening, January 22nd at the All Souls Episcopal Church, was attended by 62 members and guests. This was our annual dinner meeting. Following an excellent dinner, E. U. Condon, Director of the National Bureau of Standards, presented an address entitled "Electronics and the Future." Dr. Condon's knowledge of his subject and his keen wit kept everyone present well entertained. The main topics covered in his talk were:

1. Development of electronic devices for mathematical computation.
2. Mass spectrometers for chemical analysis and process control.
3. Detailed and thorough study of the physics of the ionosphere.
4. Cyclotrons, synchrotrons, betatrons and other devices for producing high energy particles.
5. Uranium chain reactions for production of atomic power.
6. Utilization of artifically radio-active materials for tracer studies in chemistry and for therapy.
7. The study of cosmic radiation.

After the speaker concluded his topic the group was entertained by Ralph Goetzenberger, our national Delegate, with movies which he had filmed while on a business trip in South America. The discourse which accompanied the film was both entertaining

Picture taken recently at regular meeting of the Oak Ridge Section. Standing, left to right, C. W. Covey, *Journal* Correspondent, Oak Ridge Section; N. L. Isenhour, Section Dele- e; Ronald Reamer, Taylor Instrument Companies, guest speaker at January meeting; and R. Mahoney, Section Executive Councillor. Seated, left to right, are L. L. Forward, head of e instrument division of Carbide & Carbon Corp.; W. J. Greter, Section Vice-President; H. Fowler, Section Secretary; and T. G. Dry, Membership Committee Chairman.

I S A
EMPLOYMENT SERVICE

In printing these announcements the Society assumes no obligation as to responsibility of employers. Those replying to announcements should include two copies of their reply. When testimonial documents are to be included, copies of such documents and *not* the originals should be sent. The Society regards acknowledgment by employers of all applications as an act of courtesy but can assume no responsibility for their failure to do so. Address all replies to Employment Committee, Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

—C. F. GOLDCAMP, *Chmn. Employ. Com.*

SITUATIONS OPEN

SALESMAN—old reliable manufacturer wants graduate engineer age 25 to 35, qualified by past experience to sell air operated instrument controlled diaphragm valves, pressure reducing valves, liquid level controllers and allied equipment in New York City and metropolitan area. Straight salary and expenses. Your reply in detail will be treated in strict confidence. Box 37.

INSTRUMENT MECHANIC—for all around installation and maintenance of instruments and controls. Familiarity with all makes desirable. Permanent. Location—Northern New Jersey, Middlesex County. Box 38.

TECHNICAL GRADUATE—with five years' experience in the petroleum or chemical industries. Must have knowledge of application, mechanical specification, procurement and field installation of equipment for measurement and automatic control of continuous processes. Box 39.

SALES AND SERVICE ENGINEER—by well established instrument company, to work in Dayton and Cincinnati, Ohio area. Salary and commission, plus expenses. Box 40.

GLASS BLOWER—by manufacturer of control instruments. Must be thoroughly familiar with thermometer tube making.

INSTRUMENT MECHANIC—experienced on all types pneumatic controllers by large chemical manufacturer. Location, New Jersey. Box 42.

QUALIFIED ENGINEER—young, for sales engineering department at factory, who is already trained or can be trained to handle correspondence on flow meters and flow metering problems. Must have experience on flow problems and be capable of calculating orifices. Box 43.

and informative. Upon the conclusion of the movie one had the feeling that Ralph would welcome the opportunity to work in South America. —G. M. ROLLS, *Corr.*

WAYNE COUNTY

The Wayne County Section held its regular monthly meeting on February 17 at the Presbyterian Church House in Wyandotte, Mich. The meeting started with a drawing of door prizes, which were won by H. L. Colgin and Harry Burchell.

After the reading of the minutes, two interesting films were shown. One, entitled "Time," was obtained from the Elgin Watch Company. This film showed the development of time measurement from the days of the early cave man to modern precision methods. Much interest was shown in the various methods which have been developed for measuring time.

The second film was entitled "Uses Unlimited" from the Micro-Switch Corporation. This film illustrated the manufacture and application of the Micro-Switch for thousands of measurement and control problems.

Candidates for the various local offices to be filled in the coming election were announced by the nominating committee. Results of the election will be published soon.

The March 17th meeting will feature W. H. Kidd of the Foxboro Company, whose subject will be "Control Valves." H. W. Aurez will talk on "Air Operated Controls" at our April 21st meeting.

—W. G. BAKER, *Corr.*

Who's Who in the I. S. A.

C. OWEN FAIRCHILD

The background of Charles Owen Fairchild has eminently fitted him for the presidency of the Instrument Society of America, to which post he was elected in September, 1946, at the first National Instrument Conference and Exhibit in Pittsburgh. Born February 27, 1890, in Marinette, Wisconsin, President Fairchild is a vigorous and prodigious worker, possessed of excellent health and (as always) engaged in innumerable activities in the field of science and industry.

Owen, as he is known to his associates, is the author of thirty some published papers, including a 21,000-word article on "Thermometry" in press for Encyclopedia Britannica. Probably his most notable contribution in this field, however, was his initiating, and acting as chairman of, the 1939 Temperature Symposium, sponsored by the American Institute of Physics.

His education includes degrees of B.S. in Chemical Engineering, Rose Polytechnic Institute, in 1912 and M.S. in Physics (also Rose Polytechnic in 1920. In 1915 he joined the scientific staff of the National Bureau of Standards, where he served as Assistant Physicist, and where he became Physicist in 1920.

In 1926 he became Director of Research for the C. J. Tagliabue Manufacturing Company (now a division of Portable Products Corporation) in Brooklyn, N. Y., which position he held until 1946. Early in 1946 he chose Consulting Engineering as a vocation.

Owen is a member of the American Physical Society (Fellow), the Optical Society of America, the American Society of Mechanical Engineers, the American Ceramic Society, the American Society for Metals, the American Society for the Advancement of Science, the American Geographic Society, the American Society for Testing Materials, and the Instrument Society of America. He was president of the New York Society for Measurement and Control (1942-44), which is now the New York Section of the I.S.A. During the past few years he has been studying the growth of physics in industry, the management of industrial research and its relation to general management, and the development of instrumentation as a field of its own. As a result of these activities and of his intense interest in the advancement of instrumentation, he was made vice-chairman in charge of Program of the Gibson Island Conference on Instrumentation in 1946, and is the 1947 Chairman of same. He was one of the pioneers and an indefatigable worker in the formation of the Instrument Society of America, and informs us that he is proud to be associated with the record of rapid growth and early success of the I.S.A., destined to become a great Society.

A perusal of President Fairchild's personal record reveals the following additional facts: Married, no children; Mason, member Alpha Tau Omega, Presbyterian, and (until the war started) member St. Albans Golf Club; Hobbies: piano, golf and tinkering in his home laboratory. (Owen says he has given up all of these for the moment, and is devoting all his "spare time" to I.S.A. affairs.) Home address, 114-74 178th Place, St. Albans, Long Island, New York.

HARRY F. MOORE

Few men in the business of measurement and control have contributed more to the general good than New Jersey's delegate to the Board of Directors of the I.S.A., Harry F. Moore. At the present time Instrument Specialist at the Esso Engineering Department of the Standard Oil Development Company, Harry began his instrument career in far off Aruba in 1932 when he was assigned to take over the rapidly expending Instrument Department of the Largo Oil and Transport Company there. He took to his new work so well that he was called home two years later to take charge of Instrumentation for Standard Oil Development Company. A one-man department at first, Harry soon saw his section grow into one of the best organized and most well-informed instrument groups in the country.

Having a keen appreciation for the necessity of cooperation between manufacturers and users of instruments, Harry is among the leaders of those men in industry who have done more than their share in making available to manufacturers their knowledge and experience. Many of the fine instruments now available are the result.

Nore is this spirit confined to technical development. Realizing the advantages to be obtained by a general exchange of information and ideas, Harry played an important part in the formation of the New Jersey Society for Measurement and Control in 1942. This organization has since become the New Jersey Section of the Instrument Society of America. He served as Vice-president during the first year of its existence and was elected President in 1943. Since that time he has been a member of the Executive Committee handling such jobs as Chairman of Membership, Program, Constitution and Publicity Committees. He is at present Chairman of the Constitution Committee of the I.S.A. He is also active in the Industrial Instruments and Regulators Division of the ASME, serving as Chairman of the Terminology Committee.

Harry is a graduate of the University of Illinois, holding a B.S. degree in Electrical Engineering. His leisure hours are spent with his wife and two lovely daughters at his home in Mountainside or on his near farm where he raises fruit, poultry and rabbits.

T. G. ROBINSON

T. G. Robinson was born in Charleston, Illinois, August 15, 1900, and was educated in, for the most part, Chicago schools. His technical education was undertaken at Lewis Institute of Technology, where he obtained his B.S. degree in Electrical and Mechanical Engineering.

During World War I he served in the U. S. Navy as Radio Operator and Technician, gaining considerable experience on the first radio compass used overseas. Following a few years of employment with Commonwealth Edison Company and Western Electric Company, "Robbie" joined the consulting engineering firm of Sargent & Lundy, spending some eight years on boiler plant design, power plant instruments and automatic combustion control design.

In 1932 Robbie left Sargent & Lundy to sales engineering work in instruments and controls with the J. W. Murphy Company of Chicago, and is now a partner in the firm. He and many of the men in his organization have been active members of the Chicago Section of the I.S.A. for several years.

Right now, Robbie's chief hobby is getting things done for the Second Annual Instrumentation Conference and Exhibit to take place at the Stevens Hotel in Chicago September 8-12, 1947. In Robbie's own words, the job of being Chairman of the Exhibit Committee is "no snap," but he insists that this show promises to be bigger and better in every way than the Pittsburgh Show.

B. R. TEARE, JR.

B. R. Teare, Jr., was born in 1907 in Menomonie, Wisconsin. He received his B.S. degree in Electrical Engineering in 1928 and his M.S. degree in 1928 from the University of Wisconsin.

After another year of graduate work he was employed by the General Electric Company and was associated with the advanced course engineering there. He was instructor and assistant professor of electrical engineering at Yale from 1933 to 1937 and completed the work for the degree of Doctor of Engineering in 1937.

Dr. Teare now is head of the Electrical Engineering Department at Carnegie Institute of Technology in Pittsburgh. He has been a strong proponent of instrumentation courses in technical and engineering schools for many years, and was very active in arranging for and conducting instrumentation conferences and short courses both at the 1946 I.S.A. Conference and Exhibit in Pittsburgh last September and at Carnegie Institute in 1945.

He is a member of Eta Kappa Nu, Tau Beta Phi, Phi Kappa Phi and Sigma Xi; Fellow, A.I.E.E.; senior member of the I.R.E.; and a Member of the I.S.A., Pittsburgh Section.

Dr. Teare is married and has one daughter.

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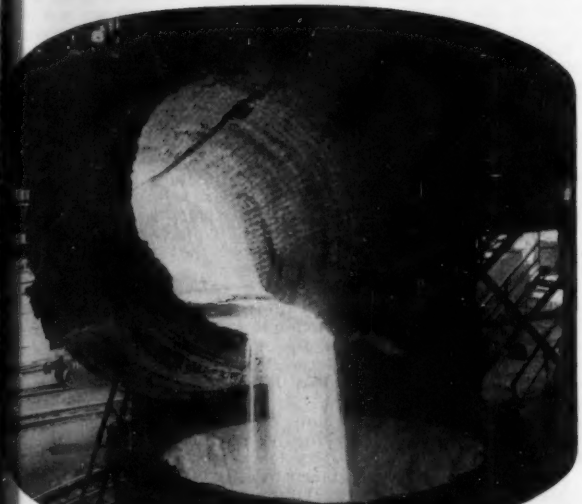

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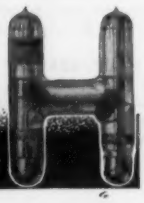

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Technical Society News

BOSTON INSTRUMENT SOCIETY

There were no vacant seats at the Boston Instrument Society monthly meeting held at 6:30 p. m. Wednesday, February 26th at Thompson's Spa in Boston.

Mr. H. S. Fairchild presided at the meeting and introduced the speaker, Mr. I. F. Kinnard, Works Engineer of the General Electric Co., West Lynn, Mass.

The subject was Analysis of Measurements, which showed the important part measurements have played in the material relationships of mankind. Mr. Kinnard remarked that many centuries before the Christian Era, methods had been devised which were remarkably accurate for measuring time, length, volume and weight. Excellent slides showed the development of measuring devices that have become diversified and complex in the modern world.

Members from Maine and Rhode Island were present at the meeting. New members are still joining the Society.

At the May meeting the question of joining the I.S.A., will be decided and this will be the annual business meeting.

—J. H. CONDON, *Corr. Sec.*

HARTFORD SOCIETY FOR MEASUREMENT AND CONTROL

"Optical Projection" will be the subject of Ed C. Polidor, Chief Engineer of Engineers Specialties Co., Buffalo, when he addresses the Hartford Society for Measurement and Control at its meeting on March 19th. The meeting will be held at the City Club, Hartford, with a dinner at 6:30 P. M. and the technical session at 8:00 P. M .

On April 16th the members will hear Roger F. Waindle of the Sapphire Products Div. of Elgin National Watch Co., whose subject will be "Sapphires Used in Industry."

HOUSTON INSTRUMENT SOCIETY

The Houston Instrument Society held its annual election meeting at the Houston Engineers' Club on 24 February, 1947. The meeting was presided over by President W. H. Fortney and new officers were elected as follows:

President, J. A. Parker (Shell Oil); Vice President, M. K. Andersen (Carbide & Carbon); Secretary, R. W. Fritzsche (Fischer & Porter); Treasurer, C. W. Bates (Humble Oil); Chairman of Constitution Committee, C. L. Shultz (Shell Oil); Chairman of Program Committee, Brant Rawson (Maintenance Engineering Co.); Chairman of Membership Committee, J. R. Seydler (Humble Oil).

The Committee previously appointed to study the relative merits of an affiliation with the I.S.A. reported with an outline of several points that they considered objectionable. They summarized their recommendations with the statement that this is not the time for affiliating with the I.S.A., but that the time is approaching.

The March meeting will be a stag social at the Lamar Hotel on 31 March. Frank S. Carothers will be toastmaster and the Rangers will justify the existence of the Society for the Preservation of Barbershop Quartets.

Porter Hart, Dow Chemical Co., spoke on the subject of "Instruments in the Detection and Prevention of Corrosion," and proved again that our best programs are conducted by local engineers. His paper dealt with prevention of corrosion in pipelines, heat exchangers, etc., by cathodic protection, which was described as protection by the application of an electrolytic charge. Mr. Hart exhibited the copper sulphate anode and special prod-rods and instruments used in the measurement of pipe-to-soil potential, as well as instruments for the measurement of soil pH and soil conductivity. He demonstrated the Shell Development Co. "Protolog" and described the application of Dow magnesium in cathodic protection. Several interesting installations were described.

—R. W. FRITZSCHE, *Sec'y*

SOUTHERN CALIFORNIA METER ASSOCIATION

The next meeting of the Southern California Meter Association will be held March 20th at the Rio Hondo Country Club, Downey, Calif. Dinner will be at 6:30 P. M. with the technical meeting at 8:00 P. M.

PREDICTS ADVANCES IN MEASUREMENT OF QUALITY

SCHENECTADY, N. Y. — In place of large supervisory instrument control boards requiring entire buildings for their housings, perhaps the future will bring forth small instrument boards suitable for mounting on a table top before a single operator, and utilizing miniature 1" instruments. So said General Electric Engineer H. D. Middel in discussing trends in industrial instrumentation before the recent Winter Convention of the AIEE.

There may be a complete absence of the conventional wide chart or round chart paper-type recorder, said Mr. Middel. In their places, wire recorders may provide a means for recording plant performance, with audio-tone signals whose frequency is a measure of deviation. For high-accuracy indication, clock-hand type motor-driven servo instruments with a 100" effective scale length in a 4" instrument case and having a full-scale time of five seconds show real promise.

The real demand in measurement leading to automatic control is for devices which more nearly measure the quality of a process, Mr. Middel continued. Qualitative measurements are difficult, if not impossible, to obtain. Truly qualitative measurements may not be a reality for the majority of processes and materials dealt with in industry for some time, he said.

[EDITOR'S NOTE.—Some say the trend toward miniature instruments began nearly twenty years ago in the power industry and took a decided jump eleven years ago. See the front-cover photo of our March 1936 issue and its description on page 57.—MFB]

COMPUTING INSTRUMENTS DISCUSSED AT A.I.E.E. MEETING

An electronic computer that will work out complex mathematical problems 100,000 times as fast as the human brain is now being developed, it was revealed at the Winter Meeting of the American Institute of Electrical Engineers in New York City.

The high-speed computer will complete in five minutes, calculations which would take a human operator one year, according to Jay W. Forrester, associate director of the Servomechanisms Laboratory at M.I.T., where the computer is being developed under the sponsorship of the Office of Naval Research. Mr. Forrester was one of a panel of speakers describing the "mechanical brains" being developed at the six leading centers of digital computer research in the United States. He predicted that such computers will in time be used to control processes in chemical plants and "automatic factories."

The M. I. T. electronic calculator is aimed at a computing speed of 25,000 operations per second, with the ability to store and "remember" 16,000 numbers of 15 decimal digits each.

T. K. Sharpless of the University of Pennsylvania described the operation of ENIAC, the electronic numerical integrator and computer already in service there, which can calculate the trajectory of an artillery shell in less time than it takes the shell to fly its course, and which is being used by the Ordnance Department in solving problems connected with rockets, guided missiles, supersonic aerodynamics. ENIAC can multiply two ten place numbers and give 20-place answers at the rate of 333 problems per second. From its stock of stored information, it can "look up" a logarithm in 0.0008 sec.

Mr. Sharpless said that the Moore School of Electrical Engineering is developing an improved computer which will operate faster, "remember" 50 times as many numbers, and use only 1/10 as many electronic tubes instead of the 18,000 tubes in ENIAC.

A computer which employs telephone relays and prints its solutions on a typewriter was described by Samuel Williams, consulting electrical engineer formerly with Bell Telephone Laboratories, where the computer was developed.

Other speakers in the panel were Howard H. Aiken, in charge of the Automatic Sequence-controlled Calculator at the Cruft Laboratory, Harvard University; Julian Bigelow, Chief Engineer of the computer project at the Institute for Advanced Study, Princeton University; and J. C. McPherson, Director of Engineering, International Business Machines Corporation.

A.I.P. REORGANIZATION

NEW YORK CITY.—Reorganization of the American Institute of Physics and plans for a new semi-popular journal devoted to the fast-growing science and its relation to society have been announced by the Institute.

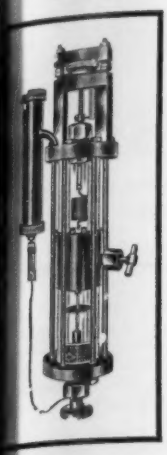
Effective immediately the 7,000 members of the five societies—The American Physical Society, The Optical Society of America, Incorporated, the Acoustical Society of America, Incorporated, the American Association of Physics Teachers, and The Society of Rheology—become members of the Institute. Heretofore the Institute has been an organization of these five Member Societies without any individual membership. Provision is also made for associate membership in the Institute, open to others interested in physics.

"No change is made in the organization, functions, and activities of the five societies," the announcement, published in *The Review of Scientific Instruments* said. "Rather the way is opened for persons interested in physics to play individually a greater part in the affairs of physics where these are of common concern to all. The new journal for which initial financing is now being sought will contain news about physicists, their meetings, their work and other activities and about similar features in related fields; information about the action of governmental and other non-physics agencies affecting physics; articles and letters presenting the views of physicists on problems of general importance; references to current literature in physics; book reviews, etc."

Technical journals in the field of physics published by the Institute and its Member Societies will remain unchanged.

Dr. Paul E. Klopsteg, Director of Research of the Technological Institute, Northwestern University, is chairman of the Institute; Dr. Henry A. Barton has been Director of the Institute since its founding in 1931. Headquarters are at 57 East 55th Street, New York 22, N. Y.

PULSAMETER



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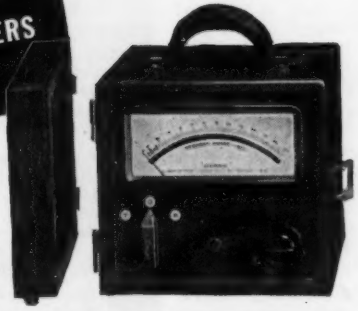

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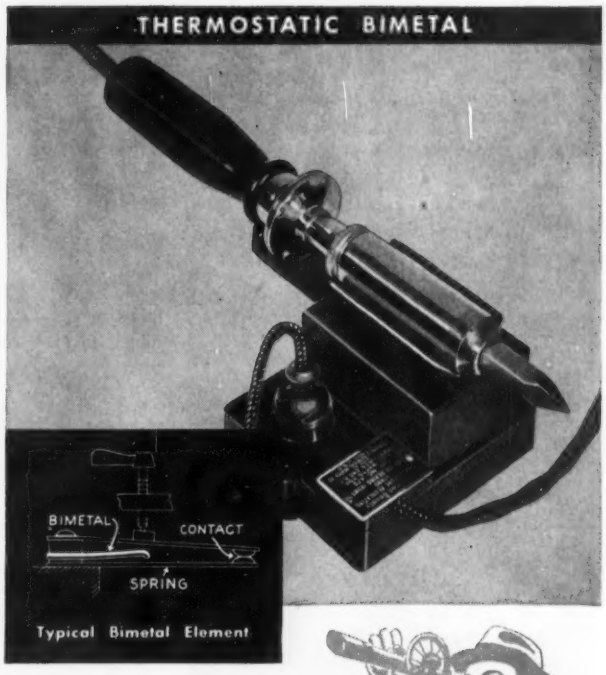

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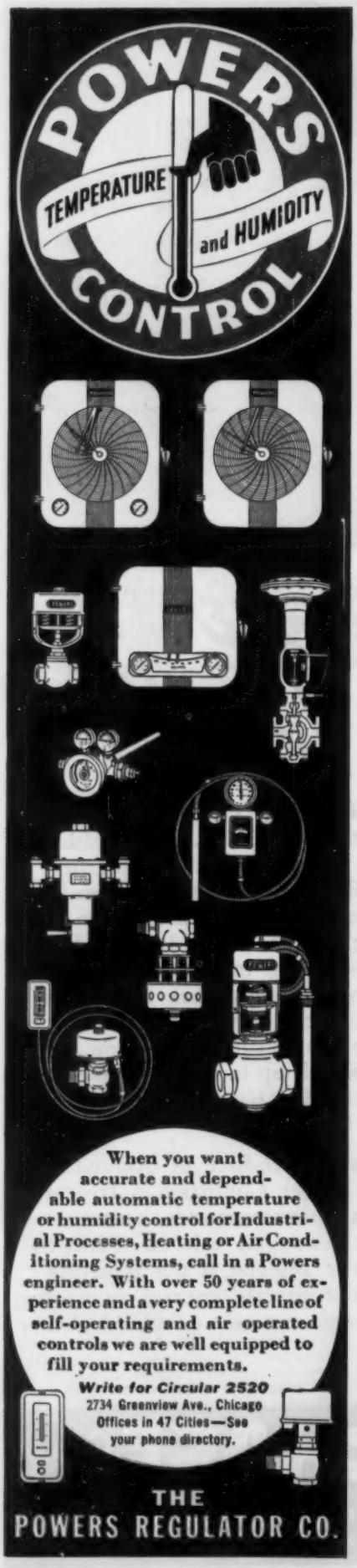
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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 291.

O-85 **Facsi Components.** 12-page 6" × 9" booklet pictures and describes line of components for use in facsimile communications equipment. Times Telephoto Equipment, Inc., 229 W. 43rd St., New York 18, N. Y.

O-86 **"Allis-Chalmers Annual Review."** 72-page 8½" × 11" Annual Review of the year 1945, issued Nov. 1946, covers engineering developments by this manufacturer during the period of reconversion. Allis-Chalmers Mfg. Co., Box 512, Milwaukee 1, Wis.

O-87 **Electric Drying Oven.** 4-page 8½" × 11" Bulletin 208 pictures and describes the Sargent electric drying oven with temperature controlled automatically to 1°C. E. H. Sargent & Co., 155-165 E. Superior St., Chicago 11, Ill.

O-88 **Barometer.** 2-page 8½" × 11" folder pictures and describes the "Eberbach" mercurial barometer, U. S. Weather Bureau professional type. Eberbach & Son Co., Ann Arbor, Mich.

O-89 **Pressure Reducing Valves.** 20-page 8½" × 11" Bulletin 461 gives engineering, operating and maintenance data on pressure reducing valves, differential valves and overflow valves for steam, air or gas services. Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.

O-90 **Telemetering.** 8-page 8½" × 11" Bulletin EA1 pictures and describes this maker's equipment for the remote indication and/or controlling of pressure, temperature, water level, etc. Control Corporation, 718 Central Ave., Minneapolis 14, Minn.

O-91 **"The Laboratory."** 32-page 6" × 9" Vol. 16 No. 3 of this house organ features an article entitled "How to Prevent Accidents in the Laboratory." Also pictures and describes various new items of laboratory apparatus. Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

O-92 **Thermometers and Pressure Gages.** 20-page 8½" × 11" Catalog No. 6707 pictures and describes maker's wall, front-of-board or flust mounting indicating thermometers, vapor-, gas- and mercury-actuated thermometers, recording thermometers and recording pressure gages. Brown Instrument Co., Wayne and Roberts Aves., Philadelphia 44, Pa.

O-93 **Test Chamber.** 4-page 8½" × 11" bulletin pictures and describes maker's relative-humidity-simulation test chambers with humidity controlled from 35°F. to 175°F. Bowser, Inc., Refrigeration Div., Terryville, Conn.

O-94 **Transmitter for Aircraft.** 4-page 8½" × 11" bulletin pictures and describes the "TA-6" communications transmitter for aircraft. Bendix Radio, Div. of Bendix Aviation Corp., Baltimore 4, Md.

O-95 **Portable Hardness Tester.** 4-page 8½" × 11" bulletin pictures and describes the "Ames" portable hardness tester, a hand-held instrument for testing rounds and flats up to 1" direct in the Rockwell scales. Ames Precision Machine Works, Waltham 54, Mass.

O-96 **Power Supply.** 2-page 8½" × 1 Bulletin Form 310 pictures and describ "Model 310-A and 310-B" electronica regulated power supplies for use wh d.c. is not available. Furst Electron 800 W. North Ave., Chicago 22, Ill.

O-97 **Pyrometers.** 4-page 8½" × Bulletin No. 2982 pictures and describ the "Alnor" pyrometers, portable py meters and electrical resistance the mometers in a variety of types. Illin Testing Laboratories, Inc., 420 N. LaSa St., Chicago 10, Ill.

O-98 **Plug Gages.** 20-page 8½" × Bulletin No. 47 pictures and describ maker's line of plug gages in plain a threaded types; ring, snap and spec gages; measuring wires, gage sets, d sets, etc. Size Control Co., 2500 Washi ton Blvd., Chicago 12, Ill.

O-99 **Electrical Connectors.** 64-pa 8½" × 11" Catalog Y46 pictures and d scribes the many types and styles ava able of "Hydent" one-piece indent ty electrical connectors. Burndy Enginee ing Co., Inc., 107 Bruckner Blvd., N York 54, N. Y.

O-100 **Instruments for the Milk Indu try.** 32-page 8½" × 11" Bulletin 389 p tures and describes maker's line of ind cators, recorders and controllers f batch-type pasteurizers, vats and tank The Foxboro Co., Foxboro, Mass.

O-101 **Thermocouples.** 36-page 8½" 11" Bulletin No. 4181 pictures and d scribes the "Alnor" line of thermocoupl protection tubes, wire and accessori Includes temperature conversion tabl and descriptions of other "Alnor" pr ducts. Illinois Testing Laboratories, In 420 N. LaSalle St., Chicago 10, Ill.

O-102 **Laboratory Hydraulic Press** 8-page 8½" × 11" bulletin pictures a describes a line of small hydrau presses and accessories for laborato and research use. Laboratory Specialt Inc., Wabash, Ind.

O-103 **Pyrometer Controllers.** 16-pa 8½" × 11" Catalog ND46 (1) pictur and describes the "Speedomax Type pyrometers for measurement and contr Includes full-size specimen of ch used. Leeds and Northrup Co., 4 Stenton Ave., Philadelphia 44, Pa.

O-104 **Renewable Fuses.** 24-page 3 × 6" Folder 206-A pictures and describ the "Trico" powder-packed renewab fuses. Trico Fuse Mfg. Co., 2948 N. St., Milwaukee 12, Wis.

O-105 **A-c. Power Supply.** 1-page 8 × 11" Form 11465 pictures and describ the "Voltbox" portable source of mete a-c. voltage and current. Superior Ele tric Co., Bristol, Conn.

O-106 **Radio Compasses for Aircra** 6-page 8½" × 11" folder pictures a describes the "MN-26 Series" manu radio compasses for aircraft. Bend Radio Div. of Bendix Aviation Co Baltimore 4, Md.

O-107 **Calibration Chambers.** 4-pa 8½" × 11" folder pictures and describ the "Bowser" laboratory units for te

g and processing at temperatures as w as −100°F. Bowser, Inc., Refrigera- n Div., Terryville, Conn.

0-108 **"Faxfilm Fax."** 2-page 8½" × " Vol. 1 No. 1 of this house organ con- ins a number of short articles on the e of the "Faxfilm" replica method of rface measurement. Faxfilm Co., Room 0, 1220 W. Sixth St., Cleveland 13, Ohio.

0-109 **Combustible Gas Indicator.** 2- ge 8½" × 11" bulletin pictures and scribes the "J-W Model L" combustible s indicator for use in laboratories as ell as plants. Johnson-Williams, Ltd., lo Alto, Calif.

0-110 **Accelerometers.** 2-page 8½" × " Catalog A-1 pictures and describes he "Statham Models R and S" acceler- eters. Includes equations for calculat- g sensitivity. Statham Laboratories, 222 Beverly Blvd., Los Angeles 36, Calif.

0-111 **Fingertip Switch.** 2-page 8½" × " Bulletin A-1 pictures and describes e "Type H" fingertip control and the ype SH" fingertip switch. International esistance Co., 401 N. Broad St., Phila- elphia 8, Pa.

0-112 **"The Announcer."** 16-page 8½" 11" Number 46-10-24 of this house rgan features an article entitled "Oil hrough the Ages." Also includes de- riptions of several new laboratory ems. Burrell Technical Supply Co., 1936 h Ave., Pittsburgh 19, Pa.

0-113 **Air Motors.** 8-page 8½" × 11" ulletin pictures and describes the ellows" air motors for power opera- on of valves and other devices formerly perated by hand. Bellows Senacon Co., 8 N. Main St., Akron 10, Ohio.

0-114 **"Sapphire as a Production Tool."** page 8½" × 11" bulletin is a reprint of article of the above title by Roger F. aindle in the *American Machinist*. Sap- hire Products Div., Elgin National Watch ., Aurora, Ill.

0-115 **Strip-chart Potentiometers.** 24- ge 8½" × 11" Catalog 15-10 pictures d describes "ElectroniK" strip-chart tentiometers employing the "contin- us-balance" principle. Also shows the eries 152C23" potentiometer controller. rown Instrument Co., Wayne & Roberts ve., Philadelphia 44, Pa.

0-116 **"General Radio Experimenter."** page 6" × 9" Vol. 21 No. 5 of this house rgan features an article describing a eak-reading voltmeter for the u-h-f. anges. General Radio Co., 275 Massa- usetts Ave., Cambridge 39, Mass.

0-117 **Electronic Instruments.** 8-page ½" × 11" Bulletin 397 pictures and scribes the "Dynalog" electronic in- ruments for the measurement and con- ol of process variables. The Foxboro ., Foxboro, Mass.

0-118 **Pulsation Dampeners.** 12-page ½" × 11" Bulletin PD-1 describes the fects and correction of gas pulsation roblems by means of the "Fluor" pul- tion dampener. The Fluor Corporation, td., 2500 S. Atlantic Blvd., Los Angeles , Calif.

0-119 **Kraus Jolly Balance.** 6-page " × 9" folder pictures and describes the Eberbach Kraus Jolly Balance" for de- rmining the specific gravities of solids. berbach & Son Co., Ann Arbor, Mich.

0-120 **Electronic Measuring Equipment.** hree 2-page 8½" × 11" catalog sheets ESD-25, etc.) picture and describe the Type PM-17 Electronic Voltohmeter," Type YYW-1 High Voltage Multiplier," nd "Type YE4A Delay Lines." General lectric Co., Electronics Dept., Sche- ctady, N. Y.

0-121 **Viscosimeter Bath.** Single sheet ½" × 11" pictures and describes the argent" viscosimeter bath which pro- des constant-temperature kinematic scosity baths. E. H. Sargent & Co., 155 . Superior St., Chicago 11, Ill.

0-122 **Facsimile Communications quipment.** 16-page 6" × 9" bulletin

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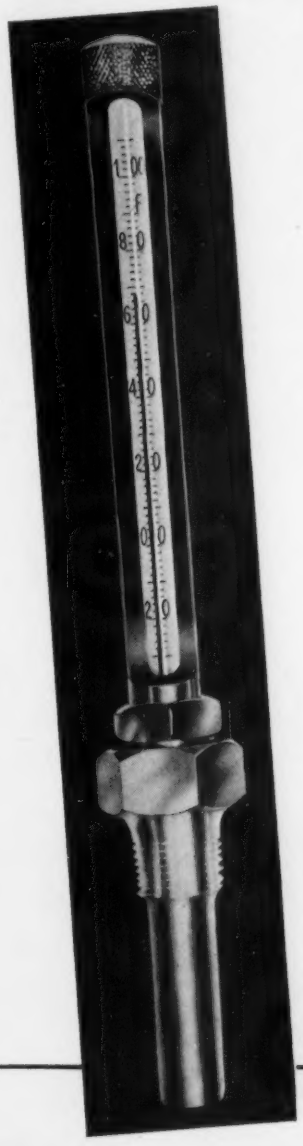

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contains a history of the development of facsimile communication and a discussion of circuit requirements. Pictures and describes maker's transmitter, recorder and transceiver. Times Telephoto Equipment, Inc., 229 W. 43rd St., New York 18, N. Y.

O-123 **Armored Rotameters.** 8-page 8½" × 11" Catalog Section 40-A pictures and describes maker's armored rotameters for high-pressure fluid flow rate measurement and control. Fischer & Porter Co., Hatboro, Pa.

O-124 **Thermometers.** 12-page 8½" × 11" Bulletin 331 pictures and describes the "Nullmatic" thermometers for indicating, recording and controlling. Moore Products Co., H and Lycoming Sts., Philadelphia 24, Pa.

O-125 **Mechanical Pressure Gage.** 2-page 8½" × 11" bulletin pictures and describes maker's mechanical pressure gage for indicating pressures in mechanical assemblies. W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill.

O-126 **Vibrometer.** 4-page 8½" × 11" bulletin pictures and describes the "Model 11-B" vibrometer for measuring electronically the vibration in industrial machinery, etc. Televiso Products Co., 7466 W. Irving Park Rd., Chicago 34, Ill.

O-127 **Resonant Relays.** 2-page 8½" × 11" Catalog No. 116 pictures and describes "Type 182" resonant relay which operates only when energized at a predetermined frequency. Stevens-Arnold Co., 22 Elkins St., South Boston 27, Mass.

O-128 **Standard Frequency Calibrator, etc.** 10-page 8½" × 11" Bulletin 6415 pictures and describes "Model RH-10 Standard Frequency Calibrator," "Model OL-15 Oscilloscope," and other instruments. Browning Laboratories, Inc., Winchester, Mass.

O-129 **"Weston Engineering Notes."** 8-page 8½" × 11" Vol. 1 No. 6 of this house organ features an article on blind approach indicators. Weston Electrical Instrument Co., 614 Frelinghuysen Ave., Newark 5, N. J.

O-130 **Thermometers.** 64-page 8½" × 11" Catalog No. 110 pictures and describes maker's line of industrial thermometers, etched-stem laboratory thermometers and thermoregulators. Philadelphia Thermometer Co., 6th and Cayuga Sts., Philadelphia 40, Pa.

O-131 **Check Valve.** Single sheet 8½" × 11" pictures and describes maker's twin seal check valve for use with any media not destructive to rubber or synthetic rubber. Mansfield & Green, 1051 Power Ave., Cleveland 14, Ohio.

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